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Adjusting Rate Structures to Rising Cost Levels

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IN these days of universal and generally accepted higher prices, a demonstration of the necessity for increased revenues for water works is possibly superfluous. Some general indication or comparison may be helpful, however.

Water is both a commodity and a transportation service. The revenues necessary to support water works therefore may be reflected to some degree in the price level structures of commodities and of transportation services.

As a commodity, water is most important. Figure 1 indicates its importance as measured in the annual tonnage produced, compared with coal, steel, wheat and cement. The tonnage of water delivered to American distribution systems in a year is 2½ times the tonnage of all the coal mined in the United States. It is approximately 20 times the tonnage produced by all the steel mills in the country in their banner year. It is 60 times the tonnage of wheat grown in a billion-bushel crop year.

As measured by the cost of the commodities on a tonnage basis, water sells on a countrywide average of about 4¢ per ton delivered. Coal in 1944 averaged $3.18 per ton, fob. mines; the average price for all steel is approximately $60 per ton; and wheat at present prices more than $60 per ton. Water is the commodity greatest in tonnage and lowest in price (Fig. 2).

As a transportation system the water works of the United States transport over 1,800,000,000 tons of water per year, or 60 per cent as much tonnage as all of the railroads of the United States. The average revenue from this transportation service by the water works (Fig. 3), is approximately

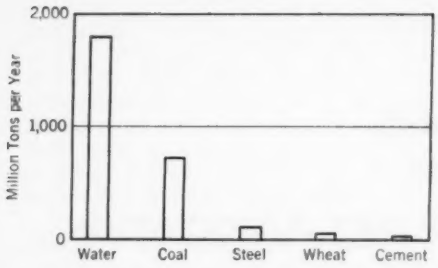

FIG. 1. Weight of Commodities Produced

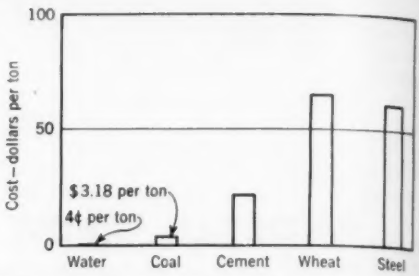

FIG. 2. Cost per Ton of Commodities

0.3¢ per ton-mile, in contrast to the 0.95¢ charge per ton-mile of American railroad freight transportation. The water works revenue also includes the cost of the commodity transported, whereas the railroad revenue does not.

Commodity Price Changes

In 1947 water is generally selling at the same price as in 1940, whereas coal, wheat, sugar and other basic commodities have increased in cost from 50 to 100 per cent or more.

Reference to commodity indexes discloses that (Fig. 4):

1. Wholesale prices increased by 60 per cent in the period from before Pearl Harbor to May 1947 (source: U.S. Labor Bureau).

2. The cost of living index increased 55 per cent (U.S. Labor Bureau—1935–39 = 100).

3. Retail prices increased 52 per cent (U.S. Commerce Dept.—1935–39 = 100).

4. Factory wages, which are reflected in the cost of commodities, increased 50 per cent (U.S. Labor Bureau).

It is apparent from these figures that commodities other than water have increased in cost as a general average approximately 50 per cent since the beginning of the war, whereas the cost of water has remained substantially static.

Transportation Cost Changes

Recently the Interstate Commerce Commission granted the railroads a 17.6 per cent increase in freight rates. Minor increases on certain classifications had previously been allowed. There is now pending application for

TABLE 1

Revenues and Operating Expenses of 100 Water Works

Year	Revenue	Operating Expenses	Revenues Less Expenses	Ratio of Expenses to Revenues
				per cent
1941	$45,301,240	$22,981,831	$22,319,409	50.7
1942	47,549,779	23,333,976	24,215,803	49.2
1943	49,725,967	24,830,284	24,895,683	49.8
1944	51,238,216	26,064,490	25,174,726	50.7
1945	51,594,197	26,423,884	25,170,308	51.3
1946	54,121,593	29,354,212	24,767,381	54.2
5-year increase, *per cent*	19.4	27.8	11.1	
1945–46 increase, *per cent*	4.9	11.1	−1.6	

additional increase of 15 to 25 per cent in freight rates, which it is claimed will only compensate the carriers for cost increases prior to 1947. A general increase of 10 per cent in interstate passenger fares has also been approved and placed in effect. These increases were found necessary for the railroads even though in 1945 the railroad revenues were more than 100 per cent above those of 1940. Water works revenues increased but 20 per cent in the same period. Substantially all water works are operating at the same rates as before the war.

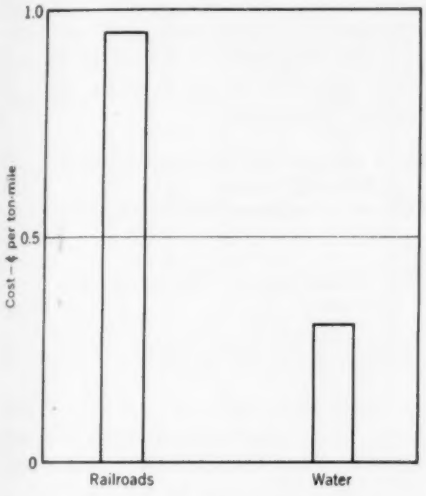

FIG. 3. Transportation Costs

Effect of War on Water Works

In an effort to ascertain the relationship between water works revenues and operating expenses from 1941 through 1946, the operating statistics of approximately 100 water works have been studied. These systems supply approximately 9,000,000 people, or more than 10 per cent of the population in the United States that is served by public water supplies. A condensed statement of the revenues, operating expenses (excluding taxes and depreciation) and revenues less operating expenses of these utilities, and of the relation of their operating expenses to revenues, is shown in Table 1. The latter relationship is also plotted in Fig. 5.

It will be noticed that the immediate effect of our entrance into the war was a reduction in the percentage relationship between expenses and revenues, and that thereafter the percentage of revenues required for operations increased at a relatively constant rate through 1945. This initial reduction was in large part brought about by the war-created shortages of labor and

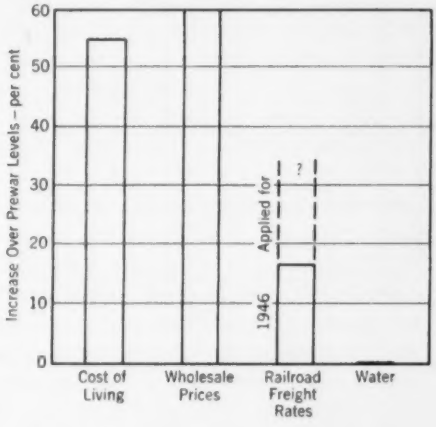

FIG. 4. Comparative Price Increases

maintenance materials, which forced maintenance expenditures to be deferred. During the latter part of 1945, however, and all through 1946, prices for both materials and labor were rising rapidly, there was more normal maintenance of facilities, and the operating ratio of expense to revenue increased 3 points, or nearly 6 per cent, in a single year. Although in 1946 the revenues exceeded the 6-year average by more than $5,000,000 per year, the excess of revenues over operating expenses in 1946 was but $400,000 more than the 6-year average. A 10

per cent increase in revenue was almost entirely absorbed by the increased cost of labor and materials. The water works systems have become engulfed in the "profitless prosperity" to which some industries have been subjected.

In the 20-year period from 1925 to 1945, the ratio of operating expenses to revenues increased 6 points. In the single year from 1945 to 1946 this ratio increased 3 points, or one-half as much as in the previous 20 years. Net revenue is being drastically reduced at a time when there is a sharp increase in the cost of the items for

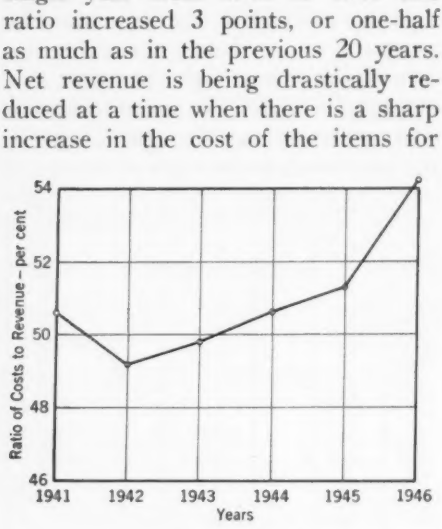

FIG. 5. Ratio of Operating Expenses to Revenues

which it has normally been expended.

In general, it is apparent that increased revenue is required by water works.

Amount of Increase Required

In a discussion of "Construction Costs and Water Rates" in 1946 (1), the author concluded that water works by and large would require at least a 20 per cent increase in rates above those of 1945 if they were to continue to furnish the same services and expand their facilities at the same rate as they had been doing in the past two decades.

It was also estimated that operating costs would increase "approximately 15.5 per cent within the very near future." For the 100 cities whose operations are summarized in Table 1, the operating costs increased 11.1 per cent for a 4.9 per cent increase in revenue from 1945 to 1946. There is still a lag in maintenance, and the figures for the calendar year do not accurately reflect costs at the end of the year.

In the year since that paper was written, costs have increased much more rapidly than previously. When reviewed in the light of 1947 costs, an increase of approximately 30 per cent in gross revenues is found necessary. This figure is derived from the following calculation:

Gross revenue per customer (average of 100 water works, 1945)	$32.10
Operating expenses before depreciation*	17.45
Net income before depreciation (per customer)	$14.65

* For 1945, but generally representative of prewar conditions because of restrictions on expenditures.

There have been two "national pattern" wage increases of about 17½ and 12½ per cent respectively, which, with correlated increases in fuel and maintenance materials, have increased or shortly will increase the prewar operating cost per customer about $4.70, reducing the estimated postwar net income from $14.65 to $9.95 per customer. This $9.95 obviously will not be sufficient to maintain and operate the properties and provide for their expansion, as the $14.65 has in the past.

From the prewar amount of $14.65 the water works normally spent about $7.35 per customer for new construction, leaving $7.30 to be spent for fixed

charges, return on investment and so on. On the assumption that at least this latter amount will be required for similar items in the future, the amount available for new construction out of the $9.95 will be reduced to $2.65 per customer. This $2.65, however, will not purchase as much construction as it would have in prewar days.

To provide the same construction facilities as cost $7.35 per customer under prewar conditions would now require the expenditure of $12 per customer. As the postwar net of

FIG. 6. E.N-R. Construction Cost Index

$9.95 will only provide $2.65 per customer for new construction after meeting other costs, there will be a deficiency of $12 − 2.65, or $9.35 per customer. This $9.35 is 29.2 per cent of the 1945 gross revenue, which averaged $32.10 per customer. Rates must therefore be increased approximately 30 per cent if water works are to progress in the future as in the past.

Necessity for Progress

A water works is never static. For at least the past two decades construction expenditures have been increasing at a rate two and one-half times as fast as the growth in the number of customers. That growth must not be permitted to suffer because of failure to provide adequately for future financing requirements. Approximately 25¢ of every $1.00 of gross water works revenue has been expended for new construction. It is as much the obligation of water works management to provide the funds necessary for betterments as to maintain existing properties. Experience has shown that the best and cheapest water service is furnished from plants that finance ordinary improvements from earnings rather than bond issues. Financing in advance from earnings is approximately 40 per cent cheaper than through bond issues.

As approximately 25 per cent of the water works revenue has been going for new construction in the past two decades, and as construction costs have greatly increased, it is obvious either that construction must be curtailed or that additional funds must be provided from revenues adequate to finance the equivalent amount of construction at present-day prices. It is important, therefore, to keep fully informed on the trend of construction costs.

Probably the most reliable index of such costs is that known as the *Engineering News-Record* construction cost index, the monthly figures for which, from 1913 to June 1947, are plotted in Fig. 6. Construction costs reflected in this index have increased more within the past year than in any other similar period in our history, except the year from June 1919 to June 1920. Following the June 1920 peak, the construction cost index recorded a 40 per cent drop in twenty months' time, a decline nearly twice as precipitous as that of 1931–33. A decline of such magnitude

is not believed likely in the face of the present entrenched position of organized labor.

Water works rates necessarily have to operate in the future. Construction of new facilities is also a future operation. Accordingly, it is important not only to keep abreast of what has happened but to be as well informed as possible on what to expect in the future, so that construction work may be programmed for economical construction and water rate structures designed to provide funds for construction as needed.

The present price level situation is a combined result of World War II and a national labor policy. Similar effects have been observed after other wars and their postwar periods probably will be reflected to some extent in the years ahead. There is accordingly reproduced as Fig. 7 (extending so as to take in the data up to June 1947) a curve showing the effect of wars on construction cost and wage indexes (1). On this figure are three lines, *A*, representing the Civil War, *B* for World War I and *C* for World War II. Each line represents the relationship of either construction costs or labor indexes, at any time after the beginning of hostilities, to the cost level at the beginning of the war. From this figure it is apparent that the post-World War I period, in which there were no price restrictions, experienced widest fluctuations in construction costs, as indicated by the top line *B*. It is apparent that curve *C*, which reflects World War II, is now at a point intermediate between the experiences of the Civil War and World War I. In both the Civil War and World War I, 13 years were required after the beginning of hostilities for the trough of the following depression to appear in the curve, and the lowest prices in both of those periods were approximately 50 per cent above their respective prewar levels.

We must be realistic. Pre-World War II construction price levels will never return. There will probably be some recession from present levels, however, as black markets in both labor and materials are dissipated by abundant supplies, as labor efficiency increases and as contingencies due to deliveries of materials and equipment disappear.

As of July 1947, the *Engineering News-Record* construction cost index

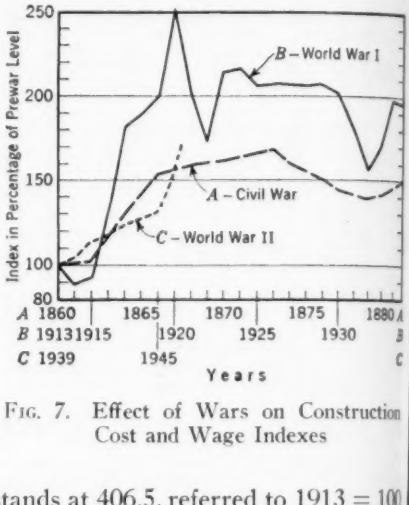

FIG. 7. Effect of Wars on Construction Cost and Wage Indexes

stands at 406.5, referred to 1913 = 100. That is equivalent to 173 with 1939 considered as 100. The actual volume of construction, as measured by structures rather than dollars, is disappointing; and it would seem probable that a drop in construction costs will be necessary before construction will proceed to gain materially on the great backlog of demand that exists. Present conditions would appear to warrant the assumption that there will be some not-too-long-deferred downward adjustment of construction costs

Whether that will be accompanied by nothing more than a mild recession remains to be seen. Such adjustments usually swing too far (as was experienced in 1921–22), and then adjust to a normal level which will be on a new plateau for some time. It is believed expansion programs for the next decade should be based upon construction costs ranging from 60 to 75 per cent above those prevailing in 1939.

Source of Increased Revenues

A discussion such as this can only deal with a general pattern, and cannot be specific. The need for increased water works revenues, however, is becoming relatively universal. The extent of the increase required varies between wide limits, depending upon such factors as:

1. Whether the individual water works property has adequate facilities or must make large capital expenditures in the near future
2. The adequacy of past revenues and whether or not funds have been accumulated to meet construction requirements
3. The extent to which fixed charges, such as interest amortization and taxes, enter into the total revenue requirements
4. How much deferred maintenance has accumulated
5. The labor situation and cost in the community, as affected by industrial competition
6. The rate of growth or expansion in facilities, and similarly related items.

It can only be stated that, as a general, nationwide pattern, it is believed that the water works systems, whether publicly or privately owned, will within the years immediately ahead need an increase in revenues of from 25 to 30 per cent if they are to continue the type of service and development which they have been providing in the past.

It must also be recognized that every rate schedule is a combination of strict equity and expediency, and that, within reasonable limits, that schedule of rates is best which, with reasonable equity between classes of customers, distributes the total cost of water service over all users with a minimum of customer resistance.

A good rate schedule discourages waste and provides every customer with the water he needs at a price which is within his means and which bears his equitable proportion of the total cost of water service.

A factor which should receive consideration when an increase in rates is contemplated is that any increase, even though generally expected, creates discussion. Thus it is better to make a rate increase sufficiently large at this time, when public psychology is favorable, than to make repeated adjustments upward in the rate schedule. One method, which has been used with satisfaction over a long period of years in one of the larger municipal plants of the country, has been to have a base rate schedule which at all times produces somewhat more than the requirements of the water works for operation and orderly expansion following a well developed program. To this rate schedule a variable percentage discount is applied. In years when the construction requirements were small, the discount was larger. In other years, when the construction program required larger expenditures, the discount was less. In this way, the customers understood that the changes were intended only to provide them with better facilities and better service, and there has been singularly little customer resistance.

If a water works, confronted with the necessity for increased revenue, currently has a rate schedule which distributes the total cost of water with reasonable equity over the various classes of customers, the procedure which will probably receive the most popular favor is the application of the same percentage increase to each class of customers. Application of this procedure, however, should only be made after carefully checking the cost of water to the largest users, in order to be sure that this percentage increase will not encourage them to leave the system and develop a separate supply—an action which might possible raise still further the cost of water to the small users.

If the present rate schedule is unsatisfactory, it will probably be desirable to develop an entirely new one. This paper is not designed to present a complete discussion of rate schedules but rather to indicate a general or short-cut approach which can be used in determining procedure. The method will first be outlined and then applied to a hypothetical plant.

Patterns of Consumption

The first consideration, of course, is determination of the gross revenue reasonably to be anticipated as necessary to cover: (a) operating and maintenance expenses, including depreciation, (b) fixed charges and (c) the average requirements for plant expansion.

In the development of a rate schedule, first consideration should be given to the small household customers as a group, and to the few largest industrial customers—the two extremes of the schedule. In general, the greater proportion of the cost of water for small customers is derived from fixed charges and labor. For the largest customers the principal costs reflect the use of fuel, power and chemicals.

In the normal city with the usual proportion of industries, the largest consuming 1 per cent of the customers will use about 50 per cent of the water sold, and 40 to 50 per cent of the

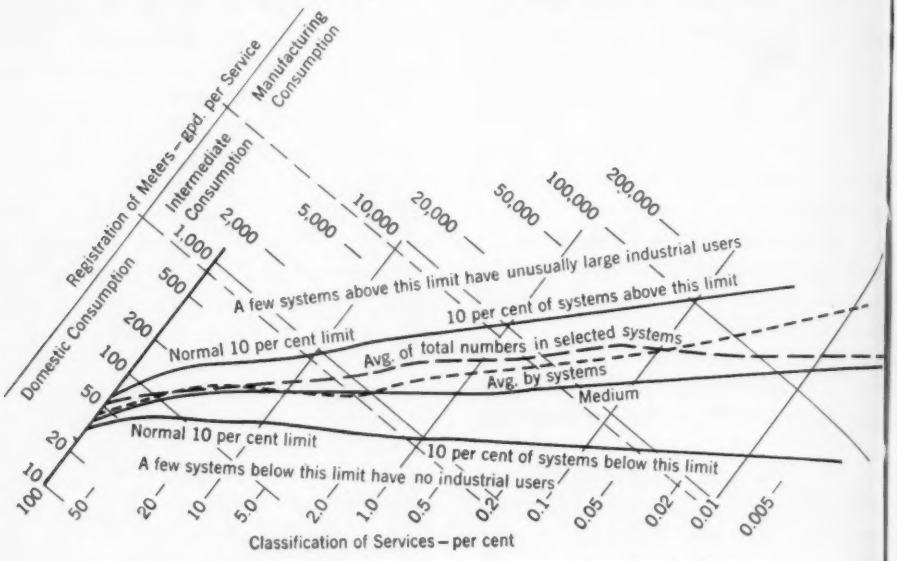

FIG. 8. Classification of Services by Consumption in 1916

smallest residential customers will use less than 3,000 gal. per month each—in the aggregate but from 5 to 8 per cent of the water sold. Consideration of the two extremes of the rate schedules will therefore usually fix the cost of 50 to 60 per cent of the water to 40–50 per cent of the customers.

ciation, headed by the late Allen Hazen (2). The study of classification of takers made in that report is reproduced herein as Fig. 8. It will be noted from this chart that in the average system of that date, 50 per cent of the customers used less than 100 gpd. each; 90 per cent used less than 400

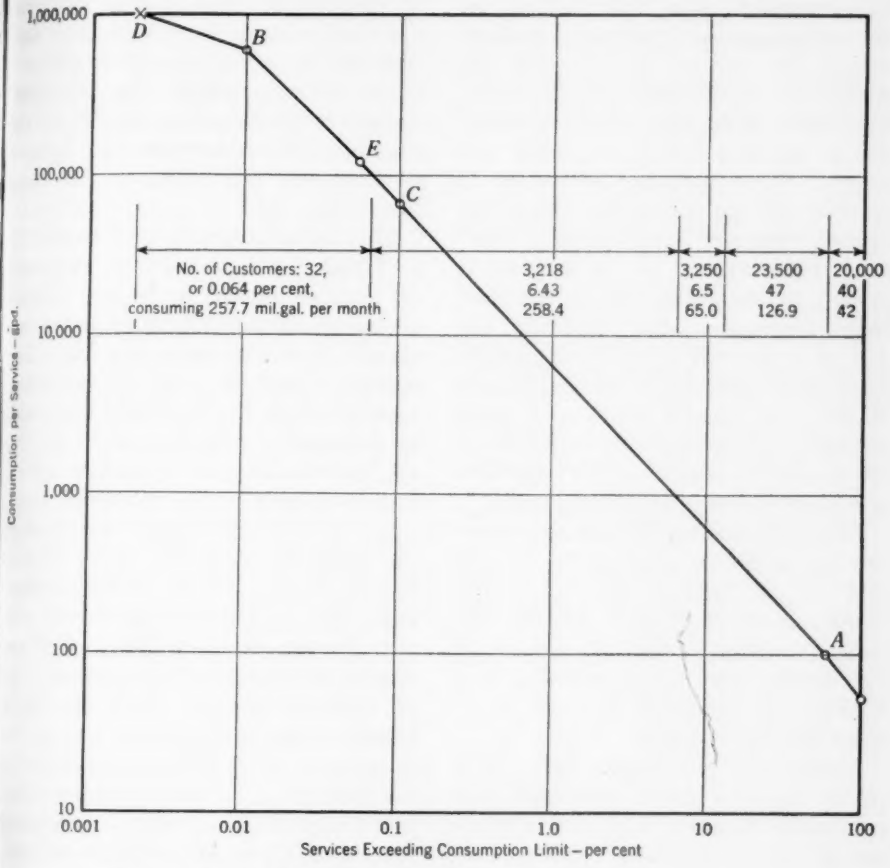

FIG. 9. Present-Day Classification of Services by Consumption

A detailed study of water rates involves a careful classification of customers. A more general classification of customers can be quickly made, however, following the procedure outlined by the study of water use in American cities made in 1916 by a committee of the New England Water Works Association, headed by the late Allen Hazen (2). The study of classification of takers made in that report is reproduced herein as Fig. 8. It will be noted from this chart that in the average system of that date, 50 per cent of the customers used less than 100 gpd. each; 90 per cent used less than 400 gpd.; and an average of only 1 per cent used more than 4,000 gpd.

Since 1916 there has been a general increase in the use of water by residential customers, averaging approximately 1 gpd. per capita per year. At present probably 40 per cent of the domestic customers in the normal Ameri-

can city still use less than 100 gpd., or 3,000 gal. per month each.

Figure 9 has been prepared to indicate the type of graph that can be developed quite readily by any water utility. It is plotted on logarithmic paper with the percentage of customers laid off along the horizontal scale and the daily consumption of water shown on the vertical scale. Point *A*, for illustration, is secured by counting the number of customers who pay minimum bills—assumed to cover consumption of up to 3,000 gal. of water per month. Their uses can be totaled to find the average amount of water used by each customer in this group. Point *B* at the other end of the diagram is plotted to show the use of the very large customers who constitute but 0.01 of 1 per cent of the total number. That, for illustration, would be the use of the fifth largest user in a plant having 50,000 customers, or would be the use of the single largest customer in a plant having 10,000 customers.

Similarly, point *C* is plotted to show the use of the smallest of the 0.1 per cent of the largest users; in other words, in a plant with 50,000 customers, it would represent the use of the fiftieth largest customer or, in a 10,000-customer plant, the use of the tenth largest customer.

Experience has shown that three points such as these determine with reasonable accuracy the pattern of the use of all customers of a given plant. When a curve is drawn through these three points and the data for intermediate uses is taken from it, the summation of all the customers' uses will usually check closely with the total water sales. As many intermediate points as may be desired or as are readily available from the customer classification in the particular plant may be plotted. The more that are plotted, the more detailed and accurate will be the analysis for that plant.

The Rate Structure

In order that the small residential users shall pay their equitable part of the total cost of water, it is necessary that the rate schedule provide either for a service charge or a minimum bill. Although a service charge is believed to be more equitable, the minimum charge is much more favorably received by the customers, and is used in about 80 per cent of American cities (*2*).

The "minimum charge" should be such that it will include the "demand" or "readiness-to-serve charge" plus an allowance for the amount of water furnished under the minimum bill. The service charge part of the minimum should include the fixed charges—such as depreciation, interest and taxes on the investment—which must be met in order to have water available at all times at sufficient pressures to meet the demands—plus the cost of reading meters, billing, accounting and collecting. The "service charge" will usually amount to from 50¢ to 75¢ per month for a residential customer. To the "service charge" there should be added a sum to cover the cost of the quantity of water which is adequate for the average small household but which is not so low as to provide an incentive for skimping on necessary water uses. That amount is generally assumed to be approximately 3,000 gal. per month. Experience has shown that, if 3,000 gal. per month is allowed for in the minimum charge, the average minimum customer will use from 2,000 to 2,250 gal. or about 75 per cent of the permissible amount. At the average rate for all water sold, this amount of water

will ordinarily amount to from 30 to 45¢ per month. When this usage cost is added to the service or demand charge, the total for a minimum bill usually falls within 75¢ to $1.25 per month. In this way the cost of water for approximately 50 per cent of the smallest customers is determined.

The cost to the largest customers is usually figured on several bases:

1. If a plant is temporarily overbuilt and has surplus water available, it may for a time sell that surplus to a large customer at its "incremental cost." This amount is computed by comparing the cost of operating with the new customer in the system with the cost of operating without him. Such "incremental costs" primarily include fuel or power for pumping and chemicals for purification. No water works can afford to sell water at this rate indefinitely.

2. If the computation of water cost for the large user charges him with his proportionate share of the fixed charges on the investment in water works property, plus the added operating cost due to his service, the large user will still have a relatively low rate and the other customers will profit through his assumption of a part of the charges which would otherwise be borne by them.

3. If, in addition to the incremental addition to operating expenses and a proportionate share of the fixed charges, there is also included in the industrial user's rate a proportionate share of the cost of providing for future expansion and facilities, the cost to him will be raised somewhat, his total rate will still be materially below the average cost of water, and all of the other customers will benefit.

By such computations the cost of water for a large customer can be ascertained.

Having thus determined the two extremes of the new rate schedule—the industrial rate and the domestic rate—the fixing of the charges for uses of water intermediate between the two may be done usually in two or three steps of approximately equal cost spread.

Hypothetical Rate Structure

The above discussion may be illustrated by a concrete example, as shown in Table 2.

TABLE 2

*Computations for Hypothetical Rate Structure**

	$ per year
Gross revenue from water sales	1,400,000
Fire protection charge	150,000
Operating expense, exclusive of depreciation and taxes	750,000
Fixed charges	350,000
Taxes	150,000
Net before fixed charges	650,000
New capital requirements	300,000

*Utility serving 50,000 customers in population of 200,000 with an average 25 mgd. of water, and having a property book cost of $10,000,000.

The customers have been classified as indicated on Fig. 9. The largest user of the 50,000 takes 1 mgd., as indicated by point *D*. The fifth largest user takes 600,000 gpd., as indicated on the diagram by point *B*. The five largest users take a total of 4 mgd. The fifty largest users take from 62,000 to 1,000,000 gpd. each. Their total use is approximately 9.4 mgd., or an average of 120,000 gpd. each, as indicated by Point *E* on Fig. 9.

There are 20,000 minimum bills which have a permissible use of 3,000 gal. per month each. Their average use is 2,100 gal. per month, or 70 gpd. The minimum bill under this set of conditions may be determined as shown in Table 3, in which a minimum bill of

$1.25 per month is indicated. This amount would allow a customer with a ⅝-in. meter to use 3,000 gal. per month.

The equivalent number of ⅝-in. meters is computed from the meters in service; the number of each size larger than ⅝-in. is multiplied by a factor that recognizes the larger demand which such meters can exert. In this hypothetical plant the computation is as shown in Table 4.

TABLE 3

Computation of Annual Minimum Cost

Readiness-to-Serve Costs	*$ per year*	*$ per year*
Fixed charges	$350,000	
Depreciation	100,000	
Taxes	150,000	
	$600,000	
	63,375* =	$9.45
Operation and Maintenance Costs		
Cost of services		0.75
Cost of meters		0.70
Meter reading, billing and accounting		1.75
Water used†		2.31
TOTAL MINIMUM COST PER YEAR		$14.96

* The equivalent number of ⅝-in. services.
† 2,100 gal. at an average cost of 11¢ per 1,000 gal.

The average revenue from all water sales is 15.3¢ per 1,000 gal. The operating cost is 8¾¢ per 1,000 gal., exclusive of depreciation and taxes, and 11¢ per 1,000 gal. with depreciation and taxes included.

Charge for Large Customers

Analysis of the operating costs for supply, distribution, purification and general and administrative costs will show that such items as fuel, power and chemical costs are affected directly by the pumpage. Certain other costs, such as those for labor in pumping and purification, are affected but slightly—varying 10 per cent, more or less—and still other costs, such as those of administration, are not affected at all. In this hypothetical water works, analysis discloses that if a large customer is added, the increase in operating expenses necessary to provide for his requirements would be about 25 per cent as much per million gallons as the average before he took service. The "incremental cost" of water would therefore be 25 per cent of 8¼¢, or 2.06¢ per 1,000 gal. If a water works had a large surplus, a rate as low as 2.06¢ per 1,000 gal. might be offered *for a short period* without increasing the cost of water to the present customers.

TABLE 4

Reduction of Various Meters to Equivalent Amounts of ⅝-in. Meters

Meter Size, *in.*	No. in Service	Demand Factor	Equivalent No. of ⅝-in. Meters
⅝	46,400	1.0	46,400
¾	1,150	1.5	1,725
1	1,250	2.5	3,750
1½	450	5.0	2,250
2	500	8.0	4,000
3	100	15.0	1,500
4	50	25.0	1,250
6	50	50.0	2,500
		TOTAL	63,375

Each long-term customer must contribute his proportion of fixed charges. If the large customer were to bear his proportionate part of the fixed charges plus the additional cost of operation imposed by his service, there would be added to this 2.06¢ per 1,000 gal. the proportionate share of fixed charges, amounting to 3.83¢ per 1,000 gal. ($350,000 ÷ [25 mgd. × 365]), or 5.89¢ per 1,000 gal. The only advantage of this rate to the present cus-

tomers would be a slight temporary reduction in their share of the fixed charges, which constitute about 25 per cent of their total cost of water. This rate would also be inequitable for a long term.

If, in addition to carrying a proportionate share of the fixed charges and the added cost of operation, the large user was to carry a proportionate share of the new capital requirement of $300,000 per year, his cost of water would be 2.06¢ for incremental operating cost plus 3.83¢ for fixed charges plus 3.27¢ for additions, or a total of 9.16¢ per 1,000 gal. He would be an attractive customer at that rate.

Instead of paying a proportionate part of new capital requirements, however, if the large user was to pay 1 per cent for depreciation, his cost would be 6.99¢ per 1,000 gallons. It would appear that this last figure of approximately 7¢ per 1,000 gal. would be fairest.

Intermediate Rates

We now have determined the two ends of the rate schedule: (a) the minimum charge of $1.25 per month, which allows for 3,000 gal. of use, and (b) the very large industrial rate at 7¢. The total revenue requirements are approximately $120,000 per month ($1,400,000 per year) from water sales.

The 20,000 minimum bills will produce $25,000 per month. If the industrial rate only applies to those using over 3 mil.gal. per month, reference to Fig. 9 would indicate that the total consumption in that step would amount to approximately 258 mil.gal., which at 7¢ per 1,000 gallons would produce $18,000 per month. The remaining $77,000 per month must be secured from water sold to customers in the other steps of the schedule. Since the total sales at the 25-mgd. rate total 750 mil.gal. per month, the consumption in the intermediate brackets is 450 mil.gal.

It is now practicable by a "cut-and-try" method to develop the intermediate steps in the rate schedule. The first step above the minimum should include practically all residential users, which means about 90 per cent of all consumers. Reference to the diagram again will indicate that 87 per cent of the customers use less than 15,000 gal. per month. It is estimated from the

TABLE 5

Final Form of Rate Structure

Step in Schedule *gal. per month*	No. of Customers	Rate per 1,000 gal. *$ per month*	Monthly Consumption *mil. gal.*	Monthly Revenue
Minimum bill (includes 3,000)	20,000	1.25	42.0	25,000
3,000 to 15,000	23,500	0.24	126.9	30,456
Next 15,000	3,250	0.16	65.0	14,300
Next 2,970,000	3,218	0.10	258.4	35,115
Over 3,000,000	32	0.07	257.7	19,927
TOTAL	50,000		750.0	$124,798
Less 5 per cent prompt payment discount on bills above minimum				4,990
MONTHLY REVENUE				$119,808
ANNUAL REVENUE				$1,437,600

curve that the total use of those above the minimum but below 15,000 gal. per month will be 127 mil.gal.

The next bracket should take in the commercial and small manufacturing users, who ordinarily require from 15,000 to 30,000 gal. per month. Reference to the curve would indicate that there are 3,250 customers in this bracket and that their consumption approximates 65 mil.gal. per month.

The use of the 32 customers using more than 3 mil.gal. per month has already been computed as 257.7 mil.gal. per month.

It is found that if the cost of water for the three brackets is 24, 16 and 10¢ respectively, with 7¢ for the few very large customers, the required amount of revenue will be produced as shown in Table 5. The cost of various quantities of water under this schedule of

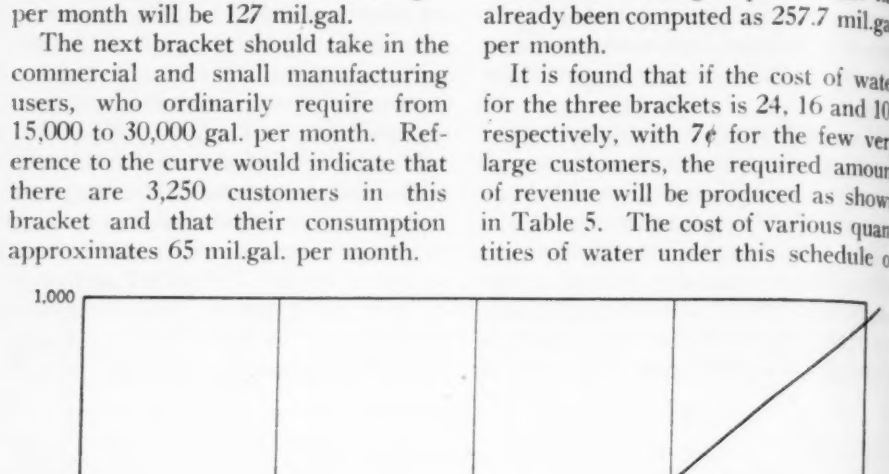

FIG. 10. Cost of Water to Various Customers

The next bracket should include all except the very few largest customers. It is therefore made to cover all uses from 30,000 to 3 mil.gal. per month and is found to include 3,218 customers. Only 32 customers would use more water than this. The total use of water by customers in the 30,000- to 3,000,000-gal. bracket is estimated from the curve to be 258 mil.gal. per month.

rates is shown diagrammatically on Fig. 10.

Rate Increases Made

Some water works have already raised rates. Syracuse, N.Y., has adopted a straight percentage increase on all steps of the rate schedule. All rates including the minimum were increased approximately 50 per cent on Jan. 1, 1947.

St. Paul, Minn., has instituted a raise with a complete rearrangement of steps and revised relationship between charges to small and large customers, on the basis of a study by A.W.W.A. Past-President Leonard Thompson. The average increase from the new schedule, effective Feb. 1, 1947, is approximately 25 per cent, ranging from 10 per cent for small customers to 40–45 per cent for large commercial and industrial users, who had previously been offered a very low rate in order to compete with the readily available individual well supplies. Mr. Thompson advises that the public reaction has been practically negligible.

Municipal water works in most states set their own rates, and the responsibility is theirs to see that revenues are adequate. In a few states municipal rates are regulated, and in practically all states privately owned utility rates are regulated by Public Utility Commissions. For those water works application for change in rates must be filed with the commission, which usually holds hearings and takes from a few weeks to several months to reach a decision. A long delay may cause irreparable damage, and it is hoped that in times such as these the commissions will not require lengthy valuation hearings but will at least grant temporary or interim increases based upon a proper showing of necessity from comparative operating figures.

Summary

The following conclusions are believed generally applicable:

1. Most water works, whether publicly or privately owned, should have increased revenues within the near future, or their service and development must be curtailed.

2. Although each water works should be separately considered, the average increase required throughout the country should be approximately 30 per cent.

3. If the arrangement of the present rate schedule is satisfactory and equitable, the simplest change is the application of a uniform percentage increase to all users. With less satisfactory schedules, the change offers opportunity for study and removal of inequities.

4. There is no completely equitable rate schedule. Each is necessarily tempered with some expediency. A reasonably equitable schedule that is generally acceptable to the customers is better than a theoretically perfect schedule the customers will neither understand nor adopt.

Acknowledgments

The author expresses his appreciation to those who furnished data or reports from which it was possible to extract the summarized figures of operations for the 100 plants analyzed in this paper.

References

1. Howson, Louis R. Construction Costs and Water Rates. Jour. A.W.W.A., **38**:739 (1946).
2. Committee on Meter Rates. Report on Waste; to Which Is Added Suggestions for Service Charges for Large Meters. J.N.E.W.W.A., **30**:453 (1916).
3. Moke, E. W. Water Rate Structures. Jour. A.W.W.A., **32**:966 (1940).

Should Public Water Supplies Be Used for Mass Medication?

By Abel Wolman

A paper presented on July 25, 1947, at the Annual Conference, San Francisco, by Abel Wolman, Prof. of San. Eng., Johns Hopkins Univ., Baltimore, Md.

THE application of chemicals to water for the purpose of clarification and the removal of organisms is one of the oldest of the arts of water treatment. Centuries have passed since people first learned by empirical observation that it was possible to improve the quality of water by the addition of various chemicals. Much of this practice was initiated long before the modern principles of chemical reaction were understood.

Conscious consideration of the possible effects on the human organism of the addition of chemicals to water is relatively recent, arising only during the last 60 years. Even today our understanding of some of these effects is still hazy.

Chemical Treatment

Water works practitioners have, however, a perfectly reasonable basis for the use of the chemicals normally listed in our texts as devoid of deleterious effect. Even where this direct evidence is limited, the positive known advantages to the populations of the world resulting from chemical processing of water outstrip by far the hypothetical and undemonstrated possibilities of objectionable results.

This is not to say that some individuals in 1947 here and abroad still do not view with caution the suggestion that waters be coagulated with alum, disinfected with chlorine or treated with copper. For example, in Great Britain recently, D. G. Davies (1) made the following comment: "until we know more about the effect of aluminum on health, water engineers should be very chary about its use." Further in his paper, he goes on to point out the "need for care in utilizing any chemicals whose action on the human frame was unknown." In a discussion of this paper, Dr. Greenshields makes a rather severe criticism of the use of alum without some limitation on effluent concentration. He suggests, however, that pure water does not occur naturally and is not even wholesome, "because of its anisotonicity with living cells. To meet the physiological need it must be impure."

Such restraint in the attitude of competent practitioners—and in 1947—represents a balancing of values and effects upon the consumer which characterizes the addition of chemicals to water. The use of chemicals in modern water treatment has brought more reasonable gains in public health to the consumer than disadvantages. These gains have been quantitative and easily demonstrable, even though

each addition of a chemical to the already long list of available materials for water processing must of course be scrutinized not only by the water works man, but by the best medical and public health advisors in continuing detailed consultation with him.

Today the water works operator makes use of alum, chlorine, copper, iodine, halazone, hypochlorite, iron salts, metaphosphates, sulfuric acid, carbonic acid, sulfur and perhaps additional materials to produce a water safe and acceptable for human consumption. The exact physiological effects of each of these have not been worked out in laboratory detail. The mass results, however, of such use of chemicals certainly seem favorable. This does not mean that further observation with more refined tools of measurement may not disclose that certain cautions and certain restraints might properly be pursued in their use. But we cannot discount the beneficent experience of hundreds of millions of people throughout the world who have been drinking waters which have been chemically processed for many decades. For these millions of people, the enteric water-borne diseases have virtually disappeared.

These prefatory comments are essential to distinguish at this point between the issues which again arise in the water works industry when we come to the important and different question of using the public water supply for mass medication.

Medication

The *Oxford English Dictionary* tells us that "medicate" means "to impregnate with a medical substance." This introduces a concept which differs, no matter how slightly, from that dominating the usual application of chemicals to water. Hitherto chemical additions, with minor exceptions, have been predicated upon the correction or modification of the quality of water, with the primary intent of eliminating deleterious substances therefrom or of modifying their character in such a way as to make the commodity safer, more palatable or physically more attractive to the consumer, or softer. When we add a chemical to a water for the frank purpose of introducing a medical substance to treat the consumer rather than to modify the water, however, we enter a different area of practice.

The problem of mass medication through the water supply has arisen on several occasions in modern history. About a quarter of a century ago suggestions for such mass medication revolved primarily around the addition of iodine to water, notably at Rochester, N.Y., in order to prevent on a mass scale the incidence of thyroidism in the general public. Controversy over the validity of the use of the water supply for this purpose was high. Medical opinion on the wisdom of the undertaking was equally divided.

The experiment was tried and finally abandoned because the expenditures and the results—perhaps, in addition, the disadvantages to some consumers—all indicated that it was unwise and unnecessary to meet the problem of iodine deficiencies of individuals through any such blanket medication program.

Today the same issue is revived by the fluorine "deficiency" of many of the public water supplies of this and other countries. The case history of the proposals for the application of fluorides to water is worth detailed analysis. Such an analysis should provide the water works operator with at

least some guiding principles on how he should meet these and similar proposals. These programs have already attained in this country so great a popularity that many superintendents are having a difficult time restraining the consuming public from forcing them to adopt a practice which may not be wholly supported by existing epidemiological evidence.

Application of Fluorides

The bibliographical record on fluorine and dental caries already totals hundreds of scientific papers. Interest in the studies of the relationships between this element and perhaps the most widespread of all diseases of mankind is international. The fact that relatively few persons escape dental caries puts the disease into a category in which virtually every individual in a community has an interest. The disease is not limited to any group. It attacks regardless of age, sex, geographical location or economic status. It begins its attack as soon as a child has teeth, and virtually every child of 10 years of age has at least one or more decayed permanent teeth. It is only natural, therefore, that a disease such as this, which transcends perhaps all other diseases in impact, should have been made the subject of extensive study throughout the world.

The role of fluorine in dental health has been elaborated perhaps most completely in two monographs (2, 3) published by the American Association for the Advancement of Science in 1942 and in 1946. Interested readers will find in those monographs authoritative summaries of present knowledge of the relationship between dental caries and fluorine.

In the monographs the present author has reviewed the implications of the fluorine content of water with respect to these problems. The following paragraphs from this survey (4) by the present author are appropriate:

> Epidemiological studies have progressed sufficiently far to indicate that the fluorides have certain protective actions against dental caries in certain age groups. In general, it is assumed that an inverse relationship exists between the prevalence rate of dental caries and the fluoride concentration of municipal water supplies. Where domestic waters show fluoride concentration of 1.0 or more parts per million the incidence of caries is low. The incidence is high where such concentrations in turn are 0.5 ppm. and less.
>
> To complicate the situation, however, an excess of fluoride frequently produces chronic dental fluorosis, commonly known as mottled enamel. The water control officer, therefore, is at once confronted with the necessity of determining the minimum effective concentration of fluorides which will produce satisfactory results without at the same time causing deleterious effects on the teeth.
>
> So far over 20 cities have been studied in this country. In view of these studies, the question naturally arises as to why water supplies deficient in fluorine should not be promptly supplemented to such an extent as to prevent the objectionable caries effects in children of the 12-14 year age group. The findings covering now some 7,257 children continue to emphasize the marked differences in the amount of dental caries between the 8 cities whose public water supplies contained less than 0.5 ppm. fluoride and the 5 cities whose water supplies contained 0.5 ppm. or more. When these comparisons are extended from the incidence of proximal dental caries to the basis of affected tooth surfaces, the rate of the cities with the lower fluoride water supplies was about 19 times as high as in the cities with the higher fluoride content.

Within the past year additional reviews of this highly significant problem have been made by Getting, by Dean, by McClure, by Jay, by William A. Jordan and by Klein (5–10). It is a reasonable conclusion from these many laboratory, field and epidemiological studies that the fluorine content of a communal water has a direct bearing on dental caries incidence. Up to the present time all of these studies have involved naturally fluorinated water, since the artificial addition of fluorine to water is of comparatively recent origin. Insufficient time has elapsed either to determine the effects of or to draw conclusions about the artificial addition of fluorine to water. Whether artificially fluorinated water will give the same results as water carrying natural fluorine is still an open question.

It is well established, however, that the natural fluorine content of drinking water varies inversely with the amount of dental caries. Since fluorine is a toxic element, excessive fluorine will produce mottled enamel. It should be remembered that both chlorine and iodine are also potentially toxic substances, if their uses are unscientifically controlled or are abused.

A more competent epidemiological conclusion is that something must be done to provide adequate dental care for all children. One of the answers to this problem is either the incorporation of fluorides in the municipal water supplies or its application topically and directly to the teeth. The American Dental Association has already expressed its official view that some such procedures are essential and will provide an additional technique for the solution of the enormous dental problem of this and other countries.

Experimental Studies

Some of the state departments of health in this country have already sanctioned the addition of fluorine to public water supplies. Without exception, however, each of these undertakings is in the nature of a mass *experiment* and *demonstration*. They are all under control observation, and none of them have been studied long enough, according to medical and dental opinion, to indicate whether or not they will perform the task for which they have been initiated without attendant objectionable results.

A summary of some of the data in the communities already applying fluorine to water is presented in Table 1. The costs attached to such an operation, at least in communities of 100,000 or less, is not a major consideration in the problem. Ordinarily the equipment costs less than $1,000. For the most part the material is applied in the form of sodium fluoride, which costs approximately $8.00 per 100 lb. The dose normally is approximately 1 ppm. of fluorine. The annual cost for a population of 100,000, assuming water consumption to be 100 gpd. per capita, would be about $4,500.

The approach to the development of such a program is well illustrated by the city of Evanston, Ill. In that city, the municipal health department approved the plans for the study on public health dentistry, with particular reference to the relationship of fluorine in the drinking water to the amount of tooth decay in school children. The local dental and medical societies approved the project, and the superintendent of schools agreed to co-operate in it. In addition, the city council approved the general plans on Nov. 5, 1945.

The enterprise, therefore, is a joint one of the dental clinic of the University of Chicago, the state and local health departments and the water department. The entire study was preceded by a detailed review of the dental decay situation not only in Evanston but in adjacent cities, all obtaining their water supplies from Lake Michigan. This source contains only traces of fluorine. As a result of these prior investigations, the conclusion was reached that dental decay in Evanston could be substantially reduced by adding 1 ppm. of fluorine to the public drinking water supply.

of the public water supply of that community, using, however—for the first time in this country—hydrofluoric acid, rather than the commonly used sodium fluoride. He has decided upon this procedure principally because the space available for the addition of the chemical in the well structure in the Madison water works is very restricted. The individual wells feed directly into the system, and there is no central point for treatment. A dose of 1 ppm. will be used in Madison.

The application of sodium fluoride to the municipal water supply was begun in Grand Rapids, Mich., on Jan.

TABLE 1

Some Fluorine Application Practices in 1947

City	Treatment Began	Chemical Form	Cost ¢ *per lb.*	Fluorine Content *ppm.*		Quantity Treated *mgd.*	Control Problems	Source of Data
				Before	After			
Brantford, Ore.	6–20–45	NaF	13.75	0.1	1.3	3.0	None	W. R. Catton
Evanston, Ill.	1–21–47	NaF	—	—	1.0	—	—	W. H. Tucker, M.D
Grand Rapids, Mich.	1–25–45	NaF	12.68	0.07	1.0	26.0	None	W. L. Harris
Midland, Mich.	1–46	NaF	10.00	0–0.2	1.0	3.0	None	Paul Stegeman
Newburgh, N. Y.	5–2–45	NaF	8.25–9.69	0.05–0.17	1.2	3.6	None	C. R. Cox
Sheboygan, Wis.	2–25–46	NaF	9.42	0.15	1.2	6.0	None	J. C. Zufelt

It is significant that the Evanston study is planned for a period of 15 years, and medical and dental opinion holds that at least 5 years will be necessary before measurable results even of a preliminary nature will be obtained.

The addition of fluorine to the water of Evanston was begun on Jan. 21, 1947, and the dental team completed on January 17, 1947, dental examinations of 4,000 Evanston children in the 6, 7, 8 and 12, 13, 14 age groups.

Aside from the communities listed in Table 1, L. A. Smith, superintendent of the water department of Madison, Wis., will shortly initiate the treatment

25, 1945. W. Leslie Harris described this practice affecting 170,000 consumers and approximately 21 mgd. of water in a recent paper (11) before the University of Michigan In-service Training Course for water works personnel. The procedures are orthodox and the annual cost, for 1.0 ppm. of fluorine, is about $11,000. The study is projected for at least 10 years and again is frankly a large-scale epidemiological investigation, the results of which await extensive parallel studies of dental caries in the young.

Aside from the applications already noted, extensive studies are under way on collateral aspects of this same prob-

lem in Massachusetts, New Jersey, Wisconsin, Minnesota and about twenty other states.

The interest in this problem is so great that similar investigations are being carried out in Japan, Australia, South Africa, England, Canada and many other areas of the world. If the addition of fluorides to water becomes an acceptable process for medical and dental reasons, there are no obstacles of cost or technological problems of operation which are significant or important enough to disbar the treatment on these grounds alone. If such mass medication through the public water supply is desirable, such demonstration awaits the results of the significant control experiments already under way. Years necessarily will elapse before the findings may be considered definitive.

Most of the informed authorities, both medical and dental, insist that universal application of fluorides to waters deficient therein is not warranted upon the basis of present evidence. They consider that a reasonable number of experimental approaches on a full municipal scale are essential over a number of years to determine the values which may be inherent in such mass medication.

At the same time these groups consider that authoritative procedures for the application of fluorine directly to the teeth should be practiced in parallel with the addition to water for comparative evaluations.

Many public health authorities feel that the direct application of fluorides to the teeth of children is a more selective and more satisfactory method of controlling dental caries in the young. William A. Jordan (9) reviews these studies of topical application at length and concludes that such a procedure has many practical values not fully shared by treatment of the public water supply, even though the cost per child exceeds $1.60. It reaches many people not supplied by public water and benefits the children of today, whereas the fluorination of water cannot be expected to benefit the present generation of children unless they are very young.

To obtain some indication of this relatively conclusive point of view of public health authorities, the author polled some 60 administrative health officers, asking whether they considered that the present evidence in this field warranted the universal application of fluorides to waters of natural content of less than 0.1 ppm. More than 90 per cent of the 60 health officers thus polled thought that nothing more than controlled experimentation was desirable at this time, in the light of available epidemiological and physiological evidence.

A similar point of view, although referring specifically to other media for the prevention of dental decay, is expressed by a recent ruling of the Council on Dental Therapeutics of the American Dental Association. The council, in considering the role of fluorine in dental caries, with special reference to synthetic fluoride tablets, concludes (12) that "the mechanism through which fluorine produces a lowered caries attack is not known . . . the different tablet preparations, though probably not dangerous in amounts recommended for daily consumption, add fluoride to diets already high in fluorine content . . . may constitute a health hazard." The council declared the compounds under discussion not acceptable for inclusion in "Accepted Dental Remedies" at this time.

Guiding Principles

Since this matter is of such widespread public interest and since many water works practitioners are literally being stampeded into the application of fluorides to water as a current procedure, it appears to the writer that a brief set of guiding principles, resting upon present information, might be useful to the water works profession. Such principles are presented herewith, not upon the basis of any personal omniscience, but on a reasonably detailed review of existing practices and of professionally informed judgments.

Compliance with these principles in no sense offers obstacles to public health progress. They are merely guides to future experimentation and action. They are in complete accord with the following conclusions (13) recently stated by David B. Ast, one of the pioneer investigators in this field:

1. Will artificially fluorinated water produce in humans the results, in kind and degree, that are caused by waters in which fluorine is found naturally? There is every reason to believe that it will, but this remains to be demonstrated.

2. Are there any cumulative effects—beneficial or otherwise, on tissues and organs other than the teeth—of long-continued ingestion of such small concentrations as 1.0 ppm. of fluorine in water? Again, there is much presumptive evidence that there are no such effects; but, until that is demonstrated, the procedure outlined in this paper must be regarded as an investigation.

3. Safe and practical methods of fluorinating potable water supplies must be developed and demonstrated.

When these three factors will have been well established, as physiological conditions, then indeed will we have taken a long step in the control of dental caries.

These suggested guiding principles, therefore, are:

Principle 1. Until the periods of controlled experimentation on water have fully elapsed and the findings on those procedures and their effect upon the exposed population have been authoritatively reviewed and assayed by competent medical, dental and public health professionals, the water works official should avoid the use of the public water supply for medication.

Principle 2. Even at that time, practices for treating the diseases of the people in ways other than through the community water supply should be thoroughly evaluated from the professional and the economic standpoints. In general, such alternative practices, inherently more specific in their nature, are to be preferred.

Principle 3. Universal application of chemicals to water for medication should be predicated upon substantial unanimity of opinion by official medical and public health agencies on the efficacy of the treatment proposed.

Principle 4. A natural prerequisite to any procedure for mass medication through the public water supply is complete concurrence between the officials of the water department and those of the health department.

References

1. Davies, Delwyn G. Standardization in Water Works Practice. *Also:* Greenshields, F. Discussion. J. Inst. Wtr. Engrs., 1:132 (Mar. 1947).
2. *Fluorine and Dental Health.* Pub. No. 19. Am. Assn. for the Advancement of Science (1942).
3. *Dental Caries and Fluorine.* Am. Assn. for the Advancement of Science (1946).
4. Wolman, Abel. Fluorine and the Public Water Supply. *Ibid.*, p. 108.

5. GETTING, VLADO A. Medical Progress: Fluorine and Dental Caries. New Eng. J. of Medicine, **234**:23, 24 (1946).
6. DEAN, H. TRENDLEY. Water-Borne Fluorides and Dental Health. *Lectures at In-service Training Course for Water Works Personnel.* Univ. of Michigan School of Public Health (May 22–24, 1945), p. 100.
7. MCCLURE, F. J. Non-dental Physiological Effects of Fluoride Domestic Waters. *Ibid.*, p. 127.
8. JAY, PHILIP. Epidemiological Aspects of Oral Lactobacillus Counts in Fluoride and Non-fluoride Areas. *Ibid.*, p. 142.
9. JORDAN, WILLIAM A. Epidemiology, Biochemical, Preventive and Control Studies. *Unpublished manuscript in seminar on fluorine.* Minnesota Dept. of Health (Sept. 25, 1946).
10. KLEIN, HENRY. Do Certain Drinking Waters Favor Dental Caries? Science, **105**:2714:4 (1947).
11. HARRIS, W. LESLIE. Experience in the Application of Fluoride to a Public Water Supply. Lectures at In-service Training Course for Water Works Personnel. Univ. of Michigan School of Public Health (May 22–24, 1945), p. 148.
12. A.D.A. Council Rules on Bone Meal and Fluorine Products. Am. J. Pub. Health, **37**:727 (1947).
13. AST, DAVID B. A Plan to Determine the Practicability, Efficacy and Safety of Fluorinating a Communal Water Supply, Deficient in Fluorine, to Control Dental Caries. In *Fluorine in Dental Public Health: A Symposium.* New York Inst. of Clinical Oral Pathology (1945), p. 40.

Discussions

J. C. Geiger

Director of Public Health, City and County of San Francisco.

The author has made an excellent review of the subject of adding fluorides to drinking water. It is sound and based on an exhaustive study of the available literature. In his "Guiding Principles" he has definitely brought forth facts which should be uppermost in the minds of all concerned.

It would seem that there are already enough mass experiments and demonstrations being conducted on public water supplies and, until sufficient time has elapsed and the scientific data have been analyzed, every health officer should do his utmost to prevent pressure by the general public for treatment of drinking water supplies by the addition of fluorides. Altogether too many people throughout the United States who have heard a little about fluorides in relation to teeth are clamoring for the immediate addition of fluorides to drinking waters.

It has not been uncommon in the San Francisco Health Dept. to receive telephone calls from persons who have probably read an article in some weekly magazine on teeth and fluorine. They always want to know why something is not done in San Francisco about adding fluorides to the water supply. Their impression is that all the Water Department must do is obtain a sufficient supply of the chemical compound and shovel it into the supply. Such action, in their opinion, would remove all the evils of dental caries. Every health department should be cognizant of the experimental work now being conducted so that it will be ready to give immediate, scientific and convincing answers to these inquiries from the public.

As analyses of caries incidence may be influenced by many conditions and are dependent upon some highly subjective criteria, further work will be

required before definite conclusions on the therapeutic effects of topically applied fluoride can be reached. Even if the method should prove to be effective, many questions remain to be answered before it could be generally used. Among them are: what fluoride concentration is most effective? how often and for what period should it be applied? what hazards are involved in using such a toxic substance on a broad scale? and would repeated use produce any deleterious effects on the teeth?

As the author has very thoroughly indicated, continued experimental practices must be conducted with the sanction of the medical and dental professions, under the close supervision of water works engineers and public health authorities, and in conjunction with institutions recognized in this field of endeavor.

W. C. Morse

Supt., Water Dept., Seattle, Wash.

This writer wishes to grasp the opportunity to discuss for a moment the very splendid paper just delivered. It is a long time since he has had the pleasure of seeing an idea which he thoroughly believes in so clearly expressed.

About forty years ago, at a dentists' convention, this writer heard a dentist insist that, if Seattle continued to use Cedar River water, at the end of two generations children would be born without either bone or tooth structure.

It is true that Seattle's Cedar River water is somewhat deficient in lime, having only 6 ppm., but the fact remains that this alarming second generation has arrived, and with bone enough to sweep the crew races of the nation on the Poughkeepsie River. Furthermore, at the age of 73, the writer still has his own teeth.

Of course, no one knows what effect Seattle water would have on those moving to the city, but they are invited to live there for 65 years to find out.

Anyway, the persistent campaign for the addition of lime to Cedar River water finally died.

About 30 years ago a tremendous furor was raised, not only in Seattle but in many parts of the nation, for the introduction of iodine in various forms into the water, to overcome the tendency toward goiter. Goiter is quite prevalent in an area some distance north of Seattle, and is about as prevalent in Seattle as it is in most cities.

During this period many food substances, particularly salt, were produced in iodized form, and some of them continue to be sold. It took only about two years, however, to find that there were many results—totally unexpected and unpredicted—occurring largely through the promiscuous use of iodine. That movement died quickly.

Now water works men are faced with a very strong demand that fluorides be introduced into the water supplies of various towns and cities. At present there is less known of the therapeutics of the chemical fluorine than there is about those of most other chemicals. In other words, its effects upon the system are not well understood.

Every individual has a different chemical make-up and, in consequence, a different chemical demand. Dental caries seems to be stopped by water carrying from 1 to 1.5 ppm. of fluorides; but it is also true that, immediately above that amount, the action

of the chemical causes mottling of the enamel.

It should be emphasized that if water treated by fluorides is continuously served to an individual already carrying an amount approaching the tolerance maximum, mottled enamel might result, with the ready possibility of a suit against the city and the water department management for damages. Should a suit of this sort ever be settled in favor of the plaintiff, an invitation would have been extended to every grafter with mottled enamel to move into that particular city and, at the end of a few months, to complain of the terrible condition his teeth are in because of the amount of fluoride in the water.

It might surprise some people to know that a man would have little difficulty in establishing by sworn testimony that his teeth—although now badly mottled—had been dreams of beauty upon his arrival in the particular town or city. And, just as sure as there was a person on the jury having mottled enamel, the plaintiff would receive the judgment.

Personally, the writer believes that it is not good judgment, where safety is not involved, to treat 100 gal. of water for the sake of the 1 gal. used for human consumption. The Seattle Water Dept. would not be willing to medicate its water supply until such action was fully and unanimously recommended by the U.S. Public Health Service, the State Health Dept. and the City Health Dept. Until such time, water supply men should move with great caution and little haste.

Reprints of the first three papers in this issue ("Adjusting Rate Structures to Rising Cost Levels" by Louis R. Howson, "Should Public Water Supplies Be Used for Mass Medication?" by Abel Wolman, and "Significance of Legislation Forbidding Strikes by Public Employees" by Wendell R. LaDue) will be made available for distribution from the A.W.W.A. office.

If you wish a copy of any or all of these articles to be placed in the hands of the chief executive of your municipality, the Association will be glad to co-operate. Merely send your request to the A.W.W.A. office, noting the name, title and address of the man involved, and a copy will be sent him free of charge with a cover letter indicating the source of the suggestion.

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Significance of Legislation Forbidding Strikes by Public Employees

By Wendell R. LaDue

A paper presented on July 23, 1947, at the Annual Conference, San Francisco, by Wendell R. LaDue, Chief. Engr. and Supt., Bureau of Water and Sewerage, Akron, Ohio.

ONE of the most quoted statements on collective bargaining between public employers and employees is contained in a letter dated Aug. 16, 1937, and addressed by former President Roosevelt to L. C. Steward, President, National Federation of Federal Employes. It sets forth a particular philosophy held and expressed by many today, ten years after its writing.

Roosevelt Opinion

The statement is quoted here in full, because its implications have often been misconstrued upon partial reference (italics added):

THE WHITE HOUSE, *August 16, 1937*

MY DEAR MR. STEWARD:

As I am unable to accept your kind invitation to be present on the occasion of the Twentieth Jubilee Convention of the National Federation of Federal Employes, I am taking this method of sending greetings and a message.

Reading your letter of July 14, 1937, I am especially interested in the timeliness of your remark that the manner in which the activities of your organization have been carried on during the past two decades "has been in complete consonance with the best traditions of public employe relationships." *Organizations of Government employes have a logical place in Government affairs.*

The desire of Government employes for fair and adequate pay, reasonable hours of work, safe and suitable working conditions, development of opportunities for advancement, facilities for fair and impartial consideration and review of grievances, and other objectives of a proper employe relations policy, is basically no different from that of employes in private industry. Organization on their part to present their views on such matters is both natural and logical, but meticulous attention should be paid to the special relationships and obligations of public servants to the public itself and to the Government.

All Government employes should realize that the process of collective bargaining, as usually understood, cannot be transplanted into the public service. It has its distinct and insurmountable limitations when applied to public personnel management. *The very nature and purposes of Government make it impossible for administrative officials to represent fully or to bind the employer in mutual discussions with Government employe organizations. The employer is the whole people,* who speak by means of laws enacted by their representatives in Congress. Accordingly, administrative officials and employes alike are governed and guided, and in many instances restricted, by laws which establish policies, procedures, or rules in personnel matters.

Particularly, I want to emphasize my conviction that militant tactics have no place in the functions of any organization of Government employes. Upon employes in

the Federal service rests the obligation to serve the whole people, whose interests and welfare require orderliness and continuity in the conduct of Government activities. This obligation is paramount. *Since their own services have to do with the functioning of the Government, a strike of public employes manifests* nothing less than *an intent* on their part *to prevent* or obstruct *the operations of Government* until their demands are satisfied. *Such action,* looking toward the paralysis of Government *by those who have sworn to support it, is unthinkable and intolerable.* It is, therefore, with a feeling of gratification that I have noted in the constitution of the National Federation of Federal Employes the provision that "under no circumstances shall this Federation engage in or support strikes against the United States Government."

I congratulate the National Federation of Federal Employes on the twentieth anniversary of its founding and trust that the convention will, in every way, be successful.

Very sincerely yours,

(Signed) FRANKLIN D. ROOSEVELT

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As this statement has been extended to cover *all* public employees, whether engaged in governmental functions or employed in proprietary activities undertaken by governmental organizations, it may be analyzed to advantage:

1. It recognizes the need and propriety for employee organizations in public work.

2. It recognizes that the public employee's desire for a proper employer-employee relation policy is no different from the desire of employees in private industry.

3. It concedes that the public employee's views may be presented but holds that there are *special* relationships and obligations of public employees to the public itself and to the government.

4. It warns that the process of collective bargaining as usually understood (with a strike threatened if the terms are not satisfactory to the worker) cannot be transplanted into the public service.

5. It states that the *nature* of Government makes it impossible for public management, of itself, to represent fully or to bind the employer (the public) in management-labor discussions.

6. It contends that because the employee's services are functions of Government, a strike by them is nothing less than an intent to prevent the operation of Government. Such action by those who have sworn to support the Government is, therefore, considered "unthinkable and intolerable."

An editorial in the *New York Herald Tribune,* Sept. 26, 1946, stated:

> We have repeatedly urged in these columns that present labor legislation and its judicial construction be amended to differentiate between strikes which only indirectly affect the public and those, such as this one in Pittsburgh, which hit the public where it lives. The right to strike should not transcend the right of millions of human beings to the comforts and necessities of normal existence. Utilities deserve a category of their own when it comes to laws dealing with labor disputes, as recognized in the case of railroads, and among utilities should be classed all vital public services. . . . We are not arguing here for a prohibition of strikes but for *machinery that greatly discourages them* whenever the public is the principal target.

State Anti-strike Laws

It is known that many states, including New York, Ohio, Texas and Virginia, have passed laws "prohibiting" strikes of public employees and declaring such action to be "against the public policy."

Upon signing the New York state bill which calls for automatic dismissal of striking public workers of the state and its political subdivisions, Governor Dewey is reported to have said that such strikes could (not would) lead to anarchy through a paralysis of government and of all society, and that the state cannot permit such action and survive.

The near-hysteria resulting in legislation outlawing strikes by public employees may be illustrated by the experience in Ohio. Public employee anti-strike bill (Ohio 97th General Assembly S.B. No. 261—Mr. Ferguson) "provides *disciplinary* action in case of strikes by persons employed by the State of Ohio, or any political sub-division thereof, or in any other branch of the public service." Section 2 of this bill states: "No person . . . in the service of any authority, commission or board, or *in any other branch of the public service* . . . shall strike."

It seems that the last phrase, which includes "public service" without defining it, can be subject to very broad interpretation without firm understanding. The stated purpose and object of the bill is to "provide *disciplinary* action in cases of strikes" but the bill itself says: "No person . . . called a public employee, *shall* strike." Is this contradictory thinking or just "legal" verbiage? It is of interest to note the softening effect when various pressure groups start working.

Originally the bill provided that:

1. Any employee striking or seeking to persuade an employee to strike loses his position and all civil service rights.

2. Such employees may be rehired and paid a salary no larger than they received before they left their jobs, and their compensation can not be increased until after three years.

3. Such employees would be on probation for a period of five years and would serve without tenure at the pleasure of the appointing officer.

When the bill was being considered, the committee, obviously reacting to public sentiment, amended the bill * to provide that:

1. Compensation could not be increased until after a period of at least one year, instead of three years.

2. The probationary period would be two years, instead of five years.

3. Discharged persons could appeal to the courts.

Civil Service Status

The interpretation of the municipal employee's status made by civil service commissions of most municipalities generally holds that:

1. A civil service employee of the municipality is as safe in his job as is an employee under federal or state civil service.

2. His position is not guaranteed. It may be abolished for lack of funds or lack of further need.

3. Employees are not expected to play politics to hold their jobs, and it is not consistent with civil service status to take an *active* part in political campaigns.

* The text of the entire bill as passed (Amended Senate Bill No. 261) will be made available to those interested, upon application to the A.W.W.A. office.

4. Employees may be discharged upon written notice giving reason. Appeal may be made to the civil service commission, whose decisions have been declared by law to be final.

In subscribing to the Association's own Code of Practice, A.W.W.A. members find the specific pledge:

> 10. I shall not as an incident related to discussion of rates of pay or condition of employment suspend or fail to perform the duties entrusted to me nor permit water service to fail the citizens who depend upon me.

and further, in the general statement:

> I shall, having associated myself with public water supply operation, hold the public interest superior to my personal interests and I shall by my acts and by my leadership see to it that water service is maintained under both normal and emergency conditions.

Negative Approach Usual

It seems significant that all of the statements, laws, explanations and codes appear to be negative, prohibitory and almost punitive in their attitude toward the public employee.

Any such negative or "anti-" attitude expressed in law is by experience recognized to be dependent upon the desire or acquiescence of "the people" for its enforcement. If it is not wanted by large numbers of people, it will not and cannot be enforced. We have only to recall past liquor prohibition legislation, NRA and OPA at the local level, where bootlegging, violations and black markets thrived in the face of half-hearted enforcement. As President Truman recently said: "Cooperation cannot be achieved by force of law."

A recent news account directed the people's attention to the fact that the Fourth of July was not a *legal* holiday, there being in Ohio only four legal holidays for "all purposes": The Sabbath, Saturday afternoon, Labor Day and Armistice Day. All others, such as Christmas, Thanksgiving, and so on, are holidays only for "negotiable instruments" whatever they may be. This is cited to show that *custom* and *common desire* sometimes transcend the written law. Any law which thousands of citizens do not want, will become either inoperative or unenforceable. Literally hundreds of so-called "social" laws are in this category.

The idea that the law must fit the time is reflected in the divided attitude of the United States Supreme Court. Should this final judicial body follow the will of the people at the moment or should it "protect" them from wide swings in day-to-day thought? Columnist Ruth Gmeiner reports that Supreme Court Justice Wiley B. Rutledge once said: "Courts and judges owe something more than the negative duty to sit silent and blind while men go on their way to prison for want of any hint of their rights." Is a law that thousands dislike to be regarded as a "good" law; to be upheld regardless?

Comparison With Private Employment

To return to the problem affecting public employees, specifically in the utility field, there may be noted a seemingly growing unrest among public employees coupled with the inability of public management to induce the desirable type of younger men to enter the utility field. Water works executives must ask themselves these questions: Is there something specifically lacking in their house? What do men employed in water works organiza-

tions want? Wherein is the public utility employee the same as or different from the employee in private industry?

One may answer: It is evident that the public employee is a person having wants, desires and reactions comparable to those of the private employee. Both will compare and draw conclusions, during discussions with each other, about their relative ability to satisfy their desires and wishes in their particular place of employment.

The public employee has the same financial and cultural desires for himself and his family. Self-interest is one of the strongest urges found in human nature. No one can have a greater interest in others than in oneself. We never worry too much about the abstract person. Natural wisdom obviously says to us: get all you can from others (first), and then add to it, by helping yourself.

In a democratic society, all men live under, and are supposedly subject to, the same laws, regardless of employment. If this be so, then the public employee would have the same status before the courts as those in private industry. Man for man and group for group, public employees are the equal, both physically and mentally, of like groups in private industry. Why, then, are they separated and subjected to special, ofttimes punitive, legislation?

In those phases of public employment involving craftsmanship, the public and private employee often belong to the same labor organization; their skill and responsibility for support of their craft are equal. Consequently, we must ask, ought there to be a difference in their treatment by the public? Wherein might public employees be considered different from employees in private industry?

It is generally thought that public employees *always* are protected by adequate tenure of office provisions, with pensions or, in lieu thereof, an assured job on the payroll, all under the general heading of civil service. Those who are familiar with the behind-the-scenes activities of public employment know how misleading this general belief can be.

In discussions regarding rates of pay to conform to private industry, management in the public employ often resorts to the argument that they are tied financially. Typical statements are reported:

1. The budget for the year has been prepared, tax rate set and, therefore, rates of pay cannot be increased.

2. The price of service—taxes—cannot be increased due to limiting figures set by law outside the control of the local administration.

3. Top management salaries are fixed by law and it is intolerable for subordinates to exceed or even approach too closely these rates.

Frequently, however, when pressure was being exerted by organized labor and strikes were imminent, the published reports were that funds had been "found" and adjustments made. This attitude on the part of some in public management, if pursued unwisely, is very apt to make the public employee skeptical of statements of financial "hand-tying." He becomes cynical when confronted with what he calls the propaganda that he is working for the public interest and the welfare of the people and should take pride in his work. The story is told of a public employee organization to which the management presented this view; whereupon some, not affected, sardoni-

cally remarked that "they received pay and did not have to take pride in their work."

The proposition that public employees work for the public interest implies that those in private industry do not. We all know, especially in the utility field, that employees of private enterprise do work for the public interest and are as conscious of their obligations to the citizens as are those in publicly controlled and operated utilities, often more so.

Causes of Unrest

Bearing these thoughts in mind and returning to the knowledge that public employee legislation is "against" and punitive; that public employees are physically, mentally and morally like other employees; that the advantages of civil service, either to the employee or to the employers—the citizens—are, in the aggregate, not too great: what then is the significance of anti-strike legislation directed toward public employees?

Briefly, it is believed to be: first, a result of the prevailing anti-strike attitude; and, second, an expression of the American attitude of "there ought to be a law," regardless of whether it is equitable, workable or even desirable.

What then can be done to offset the demand for such legislation? The A.W.W.A., representative of both management and labor, is concerned with large numbers of public employees throughout the nation. It should be a leader in the endeavor to arrive at a safe and sure management-labor relationship in the public employee field. The Association's Public Relations Study No. 3 contains much that could be absorbed by management interested in improving employee relations, as well as general public relations.

We must endeavor to discover the cause of the growing unrest among water works employees and the apparent inability of water works management to induce desirable young men to enter public employment. We know the field is vital and interesting and should offer the employee a position of steady employment with reasonable assurance of promotion both in responsibility and financial return.

What does the public employee seem to want that is so often lacking?

1. He wants to be considered a human being, a continuing asset to be incorporated into the being of the utility, and not a commodity to be used up and discarded. "Willing Water" wants to be *of* the water works, not *with* it.

2. He wants co-operation between management and labor. The "we" and not the separative "you and me" attitude.

3. He wants, although he may not know it, patience, understanding and consideration. In its dealing with labor, management should have a sense of humor—real, not the joking kind. Management is older, wiser and more experienced. Temporarily, the employee may seem impatient. Often management, in turn, will react against this with impatience, but it must be remembered that the freedom of labor is relatively young, and, like any young being, is led by visions of immediate advantages. He does not, as yet, know how to exercise his new-found power. He has a philosophy of freedom from fear and from being "pushed around." History relates that our own Revolution gave birth to the ability of our citizens to tell traditional authority where to "head in." It took many years, however, to subordinate the new-found liberty to allow democratic

government to proceed in an orderly manner. Under such stringencies, laws should direct the youthful idea but not force it. Again, co-operation has rarely been achieved by mere force of law.

Some organizations are urging that the position of cities be strengthened by laws that bar strikes by municipal workers and bar city employment to strikers and leaders judged guilty of endangering public health, safety and welfare. Such demands might well be viewed with a certain degree of alarm by those in management interested and responsible in a function that is so vital to the public health, safety and welfare.

The Ohio Common Pleas Court of Mercer County (Docket No. 14383 decided Nov. 27, 1941) refused to issue an injunction restraining striking employees from picketing a municipally owned light plant. The Court based its decision on the fact that the village was "engaged in a proprietary function and as such has the powers of and is liable to the same law as an individual or private corporation."

The recent Taft-Hartley Act has served notice to the top labor leadership, as well as to management, that they and those for whom they pretend to speak are no longer beyond a law urged and desired by their many friends. By many it is believed that when labor grows up and assumes its rightful place beside management in American economy, both will look back on the Taft-Hartley Act as the starting point in orderly and badly needed reform on their outlook on the economic life of the country.

If the "we" attitude is to be established, public management must do its share in the undertaking. Management must restore in the worker the inspiration to work. If management of public utilities cannot find a way to do justice to public employees and to the public at the same time, it must confess to failure to sustain the social structure that has been set up. Wise management will realize that it will obtain its objective of continuous service more quickly and more surely by using tact and a basic knowledge of human behavior rather than by resorting to the techniques of "legal" interpretation. The "man-to-man" approach has been proposed as being preferable to all coercive laws.

Employee's Viewpoint

In a series of articles in *Harper's Magazine* (1), and, in a more popular vein, in *Collier's* (2), Peter F. Drucker set forth very clearly the employee's viewpoint. The reasons why men strike, as given in these articles, include their conviction that labor strife—which is not considered to be between capital and labor but rather between management and labor—is inevitable. The causes of unrest are almost always to be found in concrete policies and objective conditions. Wage disputes are but an expression of bitterness and mutual distrust in the plant. Managerial unfairness; the effects of certain types of assembly-line work; the tendency to organize work and pay schedules in such a way as to isolate the workers, or set one against the other, and thus prevent teamwork; and the economic insecurity of the worker—these four factors are given as the causes of industrial conflict.

If a genuine partnership between management and labor is to be obtained, according to Drucker, a new

approach must be worked out. Such an approach would run counter to present prejudices of management and the worker by asserting that both are human beings. Management's feeling that the worker is only interested in his pay is countered by the worker's impression that management exploits him economically to make a greater profit; the elimination of this distrust is the first prerequisite to industrial harmony. The second step is for the worker to find in his work a satisfaction beyond the mere financial reward. And, finally, the plant must offer him satisfaction in the form of recognition and prestige.

Common errors of management in attempting to obtain closer partnership with employees are to rush into print with handouts or to attempt to establish communication with the worker by the human touch of the "open door." The fact is that management does not know how the worker sees things; management does not listen to him or know how to listen; and therefore its first problem is to learn how.

Attempts to bring the worker into partnership with management through financial incentives usually fail because the payments are small, they are made in times of high earnings, when they are least needed, and the workers are not really given an understanding of the importance of increased production and profits.

The worker wants satisfaction in his work. To give him this satisfaction, management must not tell him what, in *management's* opinion, he ought to feel or want to know. The early efforts must be concentrated primarily upon non-contentious technical matters. Gradually the worker may be brought into the planning and layout of the work, and thus be shown how his own job fits into the whole product or process.

To overcome the obstacles to a labor-management partnership, therefore, it has been suggested, on the one hand, that management rid itself of the idea that its responsibility ends with the paycheck, and see the worker as a human being and the plant as a social institution in which he is a citizen. Management must look for the underlying principles rather than for trick panaceas, and the idea that a sound labor relations policy is a means to "bust" the union must be abandoned.

On their side, labor leaders must abandon the idea that their function is to protect labor against management and against society. But it should be remembered that unions have offered the worker the hope of personal and social satisfaction which management should have given him.

If both management and labor are unwilling or unable to achieve industrial peace, the common impulse is to turn to government for a solution. It should be noted that the standard definition of a public utility as "a legal monopoly affected with the public interest" is an almost perfect description of the modern large-scale union. In such matters as jurisdictional strikes, union restrictions on output and strikes against the public welfare, there must be some definite government regulation of employee and union rights and responsibilities. If there are maintenance of membership clauses in labor contracts, a man can be cut off from his source of livelihood in the same manner as a professional man whose license has been revoked. The unions thus exercise governmental

functions, and many believe that they should, therefore, be at least subject to "due process of law."

Although government action may be desirable in effecting purely financial settlements, no single over-all formula should be made for a country as large and varied as the United States. It is also urged that the government revise existing practices and policies which tend to reward labor conflict rather than labor peace.

Many such discussions and articles seem to put the blame for labor unrest upon management. To paraphrase a recent statement, however: management is worthy of being a leader when it never complains of the stupidity of the worker or the lack of appreciation of the public. Hearing these complaints is a part of management's job, and to meet them and not go down to defeat is the final proof of good management.

Last year the National Institute of Municipal Law Officers published a book entitled *Labor Unions and Municipal Employe Law* by its general counsel, Charles S. Rhyne of Washington, D.C. (3). The book, based upon a survey of 400 of the largest municipalities in the nation, reviews municipal, state and federal experience in dealing with labor unions of public employees. It covers legality of union membership by municipal and other public employees, instances in which cities can prohibit union membership (as of police), and then considers questions which are raised by union demands for labor contracts with cities. Examples of the questions upon which all available experience and authority is presented in the volume are: (1) exclusive bargaining rights for unions; (2) the closed shop; (3) unlawful preferences to unions; (4) the check-off and voluntary assignment of municipal wages to unions; (5) arbitration of disputes; (6) the right to strike; (7) the right to picket municipal property; (8) violation of civil service laws by union contract provisions; (9) delegation of public power to private labor union organizations; and (10) many other questions involving particular proposed labor union contract provisions and the authority of cities to enter into such contracts.

The chief conclusions of the book may be summarized briefly:

1. Municipal employees may organize or join unions except if the nature of their employment (police) makes union membership incompatible with their public duties.

2. Signing of contracts delegating municipal powers to labor unions, or the granting of undue preferences to unions, is considered illegal.

3. Collective bargaining, in its private industry sense, cannot be transplanted into the public service.

4. Agreements resulting in conflict with civil service or other laws are illegal.

5. The closed shop in public employment is illegal.

6. The check-off device is generally regarded as an unlawful preference in favor of the union and therefore is illegal.

7. Arbitration agreements constitute an improper delegation of municipal legal authority.

8. No right to strike exists for governmental employees.

9. Picketing which prevents or interferes with the carrying out of a city's functions is illegal.

10. The exercise of a "governmental" or a "proprietary" function in the utility field does not affect the

right or the disability to enter into a labor union contract with a union of municipal employees.

A survey of city employee-union relations was presented in *Business Week* for Feb. 22, 1947 (4). The survey pointed to the increased attention to public employee organization that had been attracted by recent strikes and threats of strikes by teachers, transportation workers and other government employees. Demands for special legislation to restrict the union rights of public employees were being heard in state legislatures. Most of these bills would: forbid any government agency from granting exclusive bargaining rights to any one union; outlaw strikes by public employees; and, although permitting them to join unions, prohibit the signing of contracts which would force them to join against their will. It was held that the refusal of cities to deal with unions on wage increases was not the result of an anti-labor attitude but rather the necessity of conforming to annual budgets.

It was shown that at least 68 municipalities had recognized unions for the first time in 1946; that all of the 14 cities in the nation with more than 500,000 population had contracts with one or more unions, and that approximately 60 per cent (or 618) of the cities with populations exceeding 10,000 bargain with some union, and that union pressures for recognition were continuing.

Remedial Measures

Confronted by anti-strike legislation, the public worker is said to look forward only to government regimentation, or draft or paternalism by private organizations, and neither of these alternatives is considered to conform to the American way of life. This point is emphasized by the law recently passed by the Congress setting up machinery for loyalty checks on all federal workers and job applicants.

It is believed that the American Water Works Association should be one of the leaders among utility management organizations to promote a forthright policy of management-worker relationship which will make anti-strike legislation inoperative by making it unnecessary.

What *must* be the cardinal points of such a policy?

First, public management must be given freedom of action in its relationship with its public utility workers. That is, it must be able to stand aloof from petty political considerations in local government.

Second, public management must show firmness and fairness in its dealing with the workers. It must not fall back on anti-strike legislation and become either a regimented taskmaster or a hypocritical paternal overseer. Likewise, if public management has the support of anti-strike legislation, the workers should have the protection of an independent body to consider and establish equitable wage rates. Such a body should also be enabled to set corresponding utility rates, so as not to hamper management in its duty to the public and the public employee.

Third, both public management and public workers must realize and carry out their responsibility to the public.

What has been said of allied activities in postwar Europe is also true of the dealings of management with workers—they are all negative. Measures, such as anti-strike legislation, are "against," not "for"; disciplinary, not

co-operative. Management has been accused of always fighting "against" the worker, and consequently it has presented Unionism, its so-called opponent, with the most precious asset in any kind of combat—the initiative.

It is suggested that the public worker be encouraged to feel that he is a human being and the master of his own fate, not helpless flotsam on the current of management control.

This digression from the subject of anti-strike legislation stems from the desire to set forth a policy, which, if *earnestly* undertaken by public management, will tend to make anti-strike legislation inoperative. The operation of much current anti-strike legislation cannot be considered good public relations. Knowledge begets understanding, and from understanding comes agreement.

If public management is extended the privileges of definite anti-strike legislation, it cannot escape the implied obligation of providing the public employee with those things which the "outside world" of the private employer has provided to the private employee.

Management is becoming more and more aware that knowledge in the field of human relations is just as vital as technological "know-how." Familiarity with the many phases of the social sciences, such as economics, psychology and sociology, is most important to men and women who deal with each other as human beings. The chief job of public management and the public employee is to "humanize" their relations in the eyes of the public they serve. This is especially to be desired since the important objective is the reaction of the public as a whole—the public attitude.

It is apparent that the American Water Works Association, through its officers and through its members, should encourage *both labor and management* to strive earnestly and continuously to obtain what is intuitively known to be the better management-worker relationship. And, in so doing, let us not fall back on that Americanism: *There ought to be a law!*

References

1. Drucker, Peter F. The Way to Industrial Peace. Harpers Mag. (Nov., Dec. 1946, Jan. 1947).
2. ———. What To Do About Strikes. Collier's (Jan. 18, 1947).
3. Rhyne, Charles S. *Labor Unions and Municipal Employe Law.* National Inst. Municipal Law Officers, Washington, D.C. (1946).
4. Anon. Business Week (Feb. 22, 1947).

Engineers' Organizations for Collective Bargaining

By Sterling S. Green

A paper presented on July 23, 1947, at the Annual Conference, San Francisco, by Sterling S. Green, Materials Engr., Dept. of Water and Power, Los Angeles.

ORGANIZATIONS of engineers for collective bargaining are still the subject of great controversy. The Taft-Hartley Act not only allows engineers and other professional employees to choose their own representatives, independently of other employees and groups, but also permits them to determine whether or not they will bargain collectively at all; and for this reason many persons feel that no need continues to exist for professional engineers to maintain bargaining organizations.

The author wishes he could agree to this view, but he cannot at present. A most decisive factor in his reluctance to do so is the information in such reports as those of Compton and Armsby (1) that by 1950–52 there will be, according to prewar standards, an overproduction of engineers and no vacancies for them to fill. The young men affected will be predominantly veterans who have looked forward and worked hard to become professional men at respectable salaries.

The Committee on Employment Conditions of the American Society of Civil Engineers is deeply concerned with what will happen if this overproduction takes place and no effort is made to absorb these young men into our industries. Perhaps it will be better for them to seek adequate salaries through professional engineering groups than to take joint action under less seasoned and less conservative leadership.

It is undoubtedly true that many of these potential professional men will be shunted off to other fields, but it is equally possible that a large portion of them will want to stay in engineering at all costs and will look to labor organizations of all types in a search for ways of obtaining engineering work at adequate salary levels.

Growth of Labor Unions

In order to understand the problem of the relationship between professional people and labor organizations it is necessary to review briefly the history of the latter. Labor organizations date back to the beginning of the Republic. The Brotherhood of Carpenters and Joiners, for instance, traces its history to a group of carpenters which formed a union in Philadelphia in 1791.

Prior to 1790 there was very little need and even less interest in the formation of employee groups for the purpose of dealing collectively with their employers. During this earlier period most manufacturing in this country was done in the home, and the proprietor customarily employed only members of his immediate family

or close friends. The proprietor also had direct control of the sale of his product and had very little competition within the limited market area in which he sold his goods. Under such conditions no great pressure was exerted upon the proprietor to reduce prices and as a result there was no need to skimp on wages.

This happy situation was changed toward the close of the 18th century, when the United States Congress adopted policies which discouraged the importation of manufactured articles from England, and the demand for these goods increased until the cottage type of industry was no longer able to supply the needs of the rapidly increasing population. Factories with production capacities too great for their product to be absorbed in the local market began to appear, and distribution or marketing became a specialized field no longer under the supervision of the factory proprietor. Improved means of transportation resulting from the building of good roads, canals and railroads extended the market areas of factories and created competition between factories in such metropolitan areas as Boston, New York, Philadelphia and Baltimore. Competing merchants in these centers exerted pressure on rival manufacturers to reduce prices. As improved manufacturing processes were not available, and as proprietors had little desire to reduce profits, prices could be reduced only by cutting wages. The common viewpoint between the proprietor and his workmen was lost at this stage.

Shortly afterwards, attempts were made by workmen to form unions and present a united front to their employers in demanding increased wages. In 1806 the journeymen cordwainers (shoemakers) in Philadelphia went on strike when their employers refused their wage demands. The employers took them to court, and the judge found them guilty of a criminal conspiracy, saying that "a combination of workmen to raise their wages" was illegal. This case established a precedent under which courts dealt with unions until 1842, when the Supreme Court of Massachusetts ruled that it was not against the law for workers to join unions unless their unions did anything that was intended to hurt the employer.

In cases brought by employers charging damage done by unions, the judge was frequently swayed in his rulings by the fact that his social and economic backgrounds were more compatible with those of the employer than with those of the workmen. Still this decision was important, for it protected employees who merely joined unions and indulged in no acts harmful to their employers from being charged with criminal conspiracy. In the period preceding this decision, unions had been growing in membership, and by 1837 five national unions had been formed: the shoemakers, printers, comb-makers, carpenters and handloom weavers.

It might be of interest to note the political objectives of unions in the period prior to 1850. These were: free schools; abolition of imprisonment for debt; universal suffrage; direct election of public officials; equal taxation; controlled banks; free public lands; factory regulations; limitation of competition by women, children and prison labor; and the universal ten-hour working day. To most of us these ambitions of the early unions seem rather conservative, but in their day each one of these issues was hotly

debated, and people who advocated them were considered radicals.

The depression of 1857 greatly reduced the membership in all unions, but in the period immediately after the Civil War many new unions came into existence as a means of combating high prices resulting from the issue of "greenbacks" and the failure of wage levels to meet the increased cost of living. Soldiers returning from the Civil War were particularly interested in joining unions which could regain for them the jobs which they gave up to go to war. Increasing immigration of people whose living standards were low and who were willing to work for low wages increased the interest of industrial workers in joining organizations which could protect their jobs from this low wage competition.

National Organizations

The introduction of modern manufacturing machinery in such industries as tailoring and shoemaking aroused the employees in the affected industries to form associations to maintain wages and prevent wholesale discharges. More and more it became apparent that purely local labor organizations were unable to exert sufficient pressure upon their employers either to achieve a uniform wage scale throughout the country or to attain the political objectives which were mentioned earlier.

The Knights of Labor, a semi-secret organization, was formed in 1869 and grew rapidly. During the 1880's the Knights of Labor, having lost their secrecy, became a national mass labor movement which included not only workers of various degrees of skill but also sympathetic farmers, professional persons and even some employers. By 1881 the conflict of interest between skilled craftsmen and mass wage earners led to the formation by the skilled workers of the Federation of Organized Trades and Labor Unions which in 1886 became the American Federation of Labor. Each national union which was affiliated with the federation had its own constitution, its own rules for internal government and its own procedures for dealing with employers. All members had to be actively working at the trade, and other persons, even though sympathetic with the union's aims, were barred from active membership. The Knights of Labor lost prestige after a losing fight with the railroads and eventually passed out of the labor picture.

Industry-Wide Bargaining

It is of present-day interest that the first industry-wide collective bargaining was established between the unions and employers' associations in 1901 in the foundry and machinery industries. Throughout its history the AFL has adhered to the policy that unionization should be along craft lines. In contrast to this viewpoint some labor leaders felt that the growth of modern industrial organizations meant that collective bargaining could be done successfully only by unions embracing all the workers—clerical, technical and shop—in a particular industry. This controversy was the principle issue debated at the 1935 AFL convention, and permission to form industrial unions was denied by a large majority. A month after this convention, however, the presidents of eight AFL unions created a Committee for Industrial Organization "for the purpose of encouraging and promoting the organization of the unorganized workers in mass production and other industries upon an industrial basis."

The following year the AFL executive council ordered the ten unions then participating in the CIO to withdraw and later suspended them from the federation. In line with the tendency toward industrial types of organizations, and partly as a result of the provision in the National Labor Relations Act which permitted the National Labor Relations Board to determine the scope of the unit appropriate for collective bargaining purposes, many employees who had little sympathy for and no direct interest in union membership were placed in a position where their bargaining was done and their salaries and working conditions were determined by such labor organizations.

Status of Engineers

In the period immediately preceding World War II, tremendous armament plants were required to supply Britain, France and their allies with the munitions of war. Thousands of skilled engineers were required to design and supervise construction of these plants. Tremendous aggregations of labor were required to build these plants and unions seized this opportunity to multiply their membership. Soon it became apparent that many engineers and other skilled technicians were being included without their knowledge or consent in unions established on these projects. In other large industries, such as utilities, electrical equipment manufacturing, automobile production and the steel industry, many engineers and industrial scientists were likewise being included in industrial types of unions.

In 1937 the American Society of Civil Engineers became alarmed at the attempts made by trade and labor unions to interest engineering and technical employees in the advantages of joining unions affiliated with the AFL or CIO. Each of these major labor organizations had established national unions the membership of which was confined to engineers, architects, draftsmen and allied technical workers. In addition, a great many of the international unions, affiliated with both the AFL and CIO, attempted to include technical and professional employees either in separate locals or in heterogeneous locals along with their journeymen and helpers. Examples of these unions are the Utility Workers Union (CIO), United Steel Workers (CIO), International Association of Machinists (AFL), United Mine Workers (CIO), Brotherhood of Railway Clerks (AFL), and the Mechanics' Educational Association (Ind.).

A Committee on Unionization appointed by the A.S.C.E. made a survey of the labor situation and reported that a substantial number of engineers, totaling perhaps 10,000, had joined unions affiliated with the AFL or CIO, but also that a number of engineers had formed the TVA Engineers' Association, an association for engineers controlled by the engineers themselves. The report revealed that the subject of unionization of engineers was highly controversial, and, within the society itself, diametrically opposite views were found on what action should be taken about it. Some members held that a man could not be both a professional man and a member of a trade union, whereas others held that it was quite possible for him to retain high professional ideals and at the same time join with his fellows in collective action to improve working conditions or even to protect themselves against aggression by other organized groups.

A.S.C.E. Report

With a great deal of wisdom, the A.S.C.E. report comments that:

> . . . these opposing views arise from the fact that those who can see no good in unionization base their conclusions on knowledge of the bad practices of some of the trade unions rather than upon the fundamental principles upon which the unions are built. The principles are sound and now are the law of the land; those who have turned to trade unions for the solution of their economic ills hold that the bad practices can be eliminated. It would be a serious mistake for the society to set up any bar against the efforts of these men to perfect any agency that they believe will improve their economic position.

The recommendations of the A.S.C.E. committee were:

1. Membership in a trade union is primarily an economic matter and should not be considered to have a bearing on a man's qualifications for membership in the society.

2. Professional and subprofessional people are not and cannot be exempted from the provisions of the Wagner Act, and therefore the society should not attempt to have the act amended to exclude professional men from its provisions, as many engineers believe that collective bargaining could be made to work to their advantage.

3. The society should support efforts to amend the Wagner Act to clarify the position of professional men under it.

4. Engineers have organized or have joined existing trade unions in the belief that they could better their economic position thereby. These existing trade unions are far from ideal to represent engineers in collective action and therefore the society should be prepared to co-operate with other founder societies in the establishment of agencies to represent engineers in collective action in a dignified professional manner whenever necessary.

5. To minimize the need for collective action by engineers, the society should adopt a schedule of grades and minimum compensation.

Provisions of Wagner Act

Experience has shown that this committee report was sound in all respects, except that it failed to recognize the limitations which the Wagner Act placed upon the participation of the society in collective bargaining matters. The Wagner Act was designed to prevent the formation of so called "company unions," and the interpretation of such provisions has been to eliminate the society or any other national professional society from direct participation in the formation of collective bargaining groups because these societies include both employees and employers within their membership. The act specifically barred the contribution of funds or the participation by an employer in a labor organization. Such financial or other participation could be used as a basis of a charge of unfair labor practice if the financial assistance were given by an employer to an organization of his own employees, or it can be used to raise a charge of employer domination if funds from a group of employers were mingled with funds raised by employees in the support of their own labor organization.

To comply with the provisions of the Wagner Act barring employer domination of labor organizations, the A.S.C.E. Committee on Employment Conditions recommended in its report of October 1943 that, in those places where collective action on the part of

engineers was needed to offset the organizing activities of labor unions, the employee engineers themselves should form groups and units for the purpose of carrying on collective bargaining with their employers. It was recommended that, in general, the area to be served by each group should be coextensive with the area served by the local sections of the society. Within two years after this report was made, thirty of the local sections of the A.S.C.E. had adopted amendments to their constitution or had otherwise provided for the formation of such collective bargaining groups, should the need for them arise. In some twelve or fifteen areas, principally west of the Rocky Mountains, definite organizations were established and negotiations were entered into with the employers of the professional engineers in those areas. Most active of these groups are the Seattle Group, with units in the Boeing Aircraft Co. and four or five other industrial plants in and around Seattle; the Engineers' Guild of Oregon, with its membership largely employed by the city of Portland and federal agencies having offices in Portland; the Sacramento Group, likewise having a membership composed primarily of public employees; the San Francisco Area Group, with members employed by the Kaiser Co., the Austin Co., the Pacific Gas and Electric Co., and various public agencies in the Bay region; and the Southern California Group, with units in the Douglas Aircraft Co., the Southern California Gas Co., the Dept. of Water and Power and the Pacific Electric Railway, and also a considerable number of members employed individually or in such small groups that collective bargaining cannot be undertaken successfully for them.

Two other groups established in conformity with the policy of the society are the Tennessee Valley Group at Knoxville, Tenn., and the Central Ohio Group at Columbus, Ohio. In addition to groups established primarily by members of the A.S.C.E., associations of professional engineers and industrial scientists have been established by employees of the RCA-Victor Plant at Camden, N.J.; the Western Electric Co. at Newark, N.J.; the Minneapolis-Honeywell Co. at Minneapolis, Minn.; the Shell Development Corp. at Emeryville, Calif.; the General Electric Co. at Schenectady, N.Y.; the Bell Telephone Co. of Canada; and the Standard Oil Co. of Indiana, at Whiting, Ind.

Most of these groups confine their membership to professional employees and those groups established in accordance with the A.S.C.E. recommendation have adhered to the definition of professional engineering employee proposed by the society's Committee on Employment Conditions. The National Labor Relations Board has never accepted this definition, however, and has ruled that no segregation of employees based solely on training or education is acceptable and that in general a unit must be composed of all employees working in certain definite classifications rather than by selecting individual positions for inclusion in the unit. This policy on the part of the board was not clearly understood nor expressed at the time that the earlier units were established, and revisions in the conception of what constituted an appropriate unit of professional engineering employees had to be made. The delineation of a unit on the basis of function is now well understood and causes no particular hardship

in the formation of units of professional engineering employees.

It is often forgotten or not understood that the Wagner Act makes no provision for any group of employees —for example, professional engineers —to say once and for all that they do not wish to be bargained for by any group. If in one election for choice of representatives the vote were for "No Representative," this choice would not be final and definite. A few days after the employees so voted another labor organization could ask for an election in the same or a slightly different unit. A basic assumption of the Wagner Act was that all employees wanted to bargain collectively with their employer, and the machinery of the National Labor Relations Board was so arranged that any group that did not bargain for itself could quite easily find that the board had included its members in a unit so large that they had only a small chance of playing a decisive part in determining which, if any, labor organization would represent them.

This policy was a primary factor in the decision of engineers to organize their own bargaining groups. Such groups had to bargain effectively for their members, for a dummy organization set up solely to win exclusion from a union for its members was open to immediate attack as not being a proper labor organization. The Association of Industrial Scientists at Shell Development Corp. and the Association of Professional Engineering Personnel at the RCA-Victor Co. were harassed for several years by rival unions which claimed that these groups were "company unions." Under the Wagner Act it was necessary for such groups to bargain with the employer, sign a written agreement covering wages and hours, and function on behalf of the employees in the handling of grievances.

The Taft-Hartley Act includes a definition of professional employee and prohibits the inclusion of professional and nonprofessional employees in the same unit except if such inclusion is desired by a majority of the eligible professional employees. No case has yet come up in which it has been necessary to apply the definition contained in the act, and it remains to be seen what difficulties will be encountered in outlining a unit among the employees of a plant where such professional employees do not desire to be included with nonprofessional employees.

Advantages of Bargaining Collectively

Many people wonder why professional engineers have any reason or desire to ally themselves with any collective bargaining group, including groups composed solely of and controlled by professional engineers. Actually there are several very good reasons why professional engineers have chosen to bargain collectively with their employers. Sometimes working conditions have been such that it was impossible for individuals or even groups of individuals to bring to the attention of top management grievances about supervision, sanitary facilities, ventilation, lighting and other such matters. Other professional employees have felt dissatisfied because the wages of trades and crafts have crept up on—and occasionally surpassed—the salaries of professional employees. Still other professional employees have organized their bargaining groups to make a united effort to prevent their inclusion in bargaining

units dominated by nonprofessional people.

Almost always, the decision to form a collective bargaining group has been arrived at only after a great deal of discussion and with some reluctance on the part of the employees involved. Essentially professional people are individualists, and they do not tend to become strong supporters of labor organizations of any type. They prefer, if possible, to deal directly with their supervisors and to settle their grievances on their own initiative. It is only when these professional people find that their salaries have not kept pace with the wages of factory employees, or that their grievances cannot get to the ears of management, or that gross favoritism is the basis for promotions or layoffs, that they become interested in collective bargaining groups.

On the other hand, those professional employees who have had experience in dealing with their employer through collective bargaining groups feel that the advantages in such action far outweigh any possible loss to the individual in being less able to deal directly with his employer, and it is to be noted that, in general, agreements entered into by professional groups specifically retain for the individual the right to deal directly with his employer on a great many subjects, including the determination of salaries within the range specified by the contract.

Conclusion

It can be said that engineers' organizations for labor bargaining have filled a definite need during the last ten years in helping professional engineers to maintain a proper salary scale and proper working conditions without the need of affiliation with industry-wide labor unions. Such organizations will continue to grow as long as these needs exist. The necessity for professional organizations will diminish in the minds of professional engineers when management establishes policies of uniformity of salary for comparable types of work and of recognition of the ability of the individual, with promotions based upon such ability and outstanding effort; and when management can eliminate the employee's fear that opposition to or discussion of company policies will react adversely to the opportunity of the individual for advancement in the organization.

References

1. Compton, K. T. et al. The Outlook in the Demands for and Supply of Engineering Graduates. J. Eng. Educ., **37**: 1: 25 (1946).
2. Armsby, H. H. A Re-examination of the Compton Report in the Light of Enrollment in Engineering Curricula, Fall of 1946. J. Eng. Educ., **37**:9: 67 (1947).

Upgrading the Water Works Industry

By John H. Murdoch Jr.

A paper presented on July 23, 1947, at the Annual Conference, San Francisco, by John H. Murdoch Jr., Counsel and Vice-President, Water Works Service Co., Inc., New York.

NOW and then it is well for water works men to remind themselves of some of the new problems which face them in their work, of some of the ways in which those problems differ from those which their predecessors faced, of the new skills and personal characteristics required for water works operations in view of these new problems, and so to appreciate the need and the opportunity for personnel of the very highest quality. Discussion of official recognition of water works skills through the issuance of licenses or of securing public recognition of the relative importance of the industry through public relations campaigns is outside the scope of such an effort. The author believes that primary importance should be assigned to the building up of individual skills and personal character and that the accomplishment of these goals will be followed by official and public recognition. The emphasis should be on self-improvement.

Water Works Labor

General labor unrest, unionization, advancing wages and a decreasing supply of common labor present a new problem, the solution of which offers an opportunity and a challenge to work matters out to the advantage and improvement of the industry.

Much traditional water works practice developed in the period from 1880 to 1900, when most water works systems were constructed. It was a period when the labor force in the United States was growing rapidly and when most of the additions to the force were common laborers. Common labor was plentiful and cheap, and American water works were largely built and operated by that cheap labor. Ditches were dug with pick and shovel, and pump station boilers were hand-fired. As late as the 1920's, water works were able to hire men for 40¢ an hour, and almost all mains and services were laid by hand labor. During the depression of the 1930's, low wages were the rule, and many felt in duty bound to employ the cheap labor inefficiently, in order to spread the available work.

Now conditions have changed, but methods of operation have not changed rapidly enough to keep pace. In the period from 1900 to 1940, when the population of the United States increased by more than 55 million, the total labor force increased by 14 million, of which only 1 million was contributed by unskilled labor. It has been calculated that in the same period the output per man-hour more than doubled, largely because the power output available to supplement man-

power more than trebled. Relatively speaking, there is not now as much labor available, and the water works industry must compete for the force needed against industries which use the force efficiently and can afford high wages. According to the *Engineering News-Record,* the average common labor wage rate for twenty cities in 1940 was 69.9¢ per hour. In December 1940 the figure was 71.1¢. By May 1947 it had risen to $1.146. In some labor markets water utilities are now paying more than $1.25 per hour for ditch-digging and pipeline labor. At these labor rates, and with the selling price of water service at prewar levels, it is obvious that water utilities cannot continue to have such work done by the old methods. Upgrading is essential.

Progressive management is doing much to compensate for changes in the work force by the use of better equipment, but even with the best of management, much improvement in methods is needed. For large pipeline jobs, power ditchdiggers and power hoists are standard practice. Common labor either ceases to be common labor or is so stepped up in production through mechanization that it produces enough additional output to compensate for the high wages. The situation is less satisfactory with the installation of individual services or the repair of leaks. Many systems are using to good advantage such labor-saving devices as compressed-air machinery for drilling under paving and through obstructions, cutting in valves, breaking pavements and operating main line valves.

There is still too much hand labor involved in the digging of the necessary holes in the street and at the curb line. Someone should develop a service car so equipped and powered that one or two men can do all the work of cutting, digging, boring, cutting in valves and backfilling—all with power machinery. This is an opportunity for a top flight engineer in the water works manufacturing field. The progress made so far, after all, is really the result of the combination of first-class brains and discontent. It has made possible the payment of fair wages and it has upgraded the industry. The man who handles the new machinery must have some mechanical ability—something more than a good set of bone and muscles. He becomes a man who produces a satisfying amount of work and so becomes a man with the pride of accomplishment.

The same principles apply in the pumping station and the treatment plants. With advancing labor costs, labor must be made more productive through new skills and new power equipment. Remote automatic controls and push-button operation are relatively new dreams in the water works industry, but—given the brains which the developing situation requires—such dreams will be commonplace realities in the near future. The cause—a difficult problem—will be met with imagination, skill and courage, and the result will be better service at lower unit cost and a higher grade labor force.

Foremen and Supervisors

New and intricate machinery, applying new power or old power in new ways, and better grade labor require better foremen and supervisors. In the upgraded industry the foremen and supervisors must be mechanics and technicians of considerable ability.

They must know how to keep the machines operating and in the condition required for long life; they must, under the new labor laws, be the actual agents of the employer and so, to be efficient, must know the objections and policies of management and feel in sympathetic agreement with them. The more complex the entire machine of the industry becomes, the more necessary it is to have better trained, energetic and ambitious supervisors and foremen. This requirement presents an opportunity to associations, trade journals and teachers. The industry needs well-trained foremen and supervisors. They must be so well trained in human relations that they can lead a modern labor force. They must be so well trained in the details of various skills that they can train their men and keep their machines operating. They must know a great deal about plumbing and the safeguarding of water in the system. They must be trained in such matters by the industry—step by step, year by year—so that good men will come to be of even greater value to themselves and the industry.

Chemists and Engineers

There is still vastly important work that will require the best that can be secured of chemists and engineers. In the author's opinion, more problems are waiting for solution than have yet been solved. Specialists in either engineering or chemistry or their combination may be able to find fault with the illustrations to be offered, but the main thesis should emerge from any discussion that may be provoked.

The securing of adequate quantities of raw water for water works systems is a function of engineers. Reports indicate that many sections of the United States which depend on ground water sources are overdrawing the available supplies and that the water levels are falling at alarming rates. In some of these sections, industries which are vital to the life of the community depend upon the underground waters because of their chemical characteristics or temperatures. Can the engineers maintain the supplies in sufficient quantities? In the mining and industrial sections much valuable original research work and development remain to be done in maintaining or restoring water supplies adequate in quantity and quality as the raw supply for water works and also in making possible the industrial development on which advancing civilization depends. This is a field of work open to and requiring the best of engineers and chemists. The addition of such men to the field will benefit the water works industry.

Original research work remains to be done by first-class engineers in developing machinery and plants to meet modern conditions of labor and power. More work lies ahead in the design of distribution systems "to keep good water good" and to have it available when and where needed without excessive cost.

Chemists are face to face with a civilization no longer satisfied with water which is merely safe. Water must meet further physical and chemical standards to satisfy the needs of the modern city. For example, people are becoming hardness-conscious. Most domestic consumers want soft water. But perhaps industry uses the bulk of the water delivered and would not be attracted by water with the

characteristics (and higher costs) desired by domestic consumers. The loss of the industrial business means disaster to the water utility. Can water pleasing to all be delivered at a price satisfactory to all? In many places a solution has not been found, and chemists who can solve the problem are needed.

This is just one example of the need for a sound business and chemical study in reconciling the wants of the community with the needs for tailor-made industrial water. Chemists have found it necessary to remove from the entire supply of a city minute quantities of iron, ordinarily considered unobjectionable, because they clogged tiny orifices in automatic glass-bottle machines. Chemists must find a way to eliminate or reduce the aggressive or corrosive qualities of water not only under ordinary conditions, but also when raised to the high temperatures required, for example, by the automatic laundry machines now in use. Chemists must work with other scientists in developing methods for automatic filtration and treatment of raw water of varying quantity and quality, so that the proper treatment will always be given. The water works industry can use the best chemists that the schools can produce, equipped and willing to explore the unknown.

The improvement of the water works industry through more and better chemists and engineers is an endeavor in which the A.W.W.A. should take the lead. It should co-operate with the engineering colleges and universities and with the Engineering Education Association to develop courses of study designed to produce the men the industry needs. It should also be active in pointing out areas of service and rewards for outstanding men.

Top Management

Top management is the most important part of a water works organization. If top management is weak, the effect of that weakness is felt throughout the entire system. On the other hand, a strong leader who knows the problems which must be solved and who is determined to have them solved can bring order out of chaos and progress out of reaction. Modern water works conditions require such leaders, and more are needed than are now available. They must be developed, trained, and then given opportunities to demonstrate their unique value. Through such men the water works industry will be upgraded.

By top management the author means those in the operating organization in responsible charge of the entire enterprise. Top management is usually made up of a small group of officers who are closely associated and who divide the work among themselves. For the purposes of discussion and in the interest of simplicity of presentation, however, top management may be conceived as a single individual. It is recognized that, in such an approach, top management will be conceived to require a breadth and variety of characteristics seldom, if ever, found in one man.

The manager must know his water works system intimately. He must know it from the source of supply to the customer's premises. The community served must constantly be studied, so that its water supply needs can be anticipated. This study requires a sound working knowledge of industry, economics and population trends and of changes in public taste.

To be able to keep the system abreast of the community, the manager must understand the essentials of the problems, methods and goals of his engineers and chemists, so that he can make use of these men intelligently. He must have sufficient grasp of the work of others to be able to appraise it, and choose and support and develop the proper men and the best answers which they submit to him.

The executive must understand water purification. Certainly he need not be a chemist or a bacteriologist or be capable of operating a filter or treatment plant, but he must know enough to be able to understand what his technical men are trying to accomplish and to guard against inferior work by those under him. He is the one who must inspire his organization and give it leadership in the task of producing and delivering a pure water. These things he can do if he understands their importance and the many points which must be guarded. He must lead his own forces with understanding and he must educate and lead his community in support of that organization for pure water. He must also have some knowledge of hydraulics and pumping. Here he must lead and work with his mechanical and civil engineers. If he does not know enough of the subjects to keep abreast of major trends, he will have an obsolete plant and an organization discouraged or asleep. He must choose the right men, inspire them with visions of progress, and make it possible for them to go forward.

This leader must be a business man. As a business man he will be able to read financial statements and draw not merely statistics but meanings from them. He will be able to see where money is being wasted, where the expenditure of money will make the organization stronger and a better money-maker. He will know how to use the aid of bankers to keep his system financed to the best advantage. He will know that the only water works plants which can give adequate service are those which are successful as businesses, and he will be business man enough to make the one he manages successful.

Finally, he will be able to weld his associates into a team. The man worthy to manage a water works system will be modern in his approach to labor problems and in the development of personnel. Such a man will insist that all those who work with him be trained and equipped so that each carries a fair share of the total load. He will not be content with antiquated methods of work nor with a working force torn by discontent. The ideal leader will have the indispensable knack of making each of his associates a member of the team. This cannot be done by the issuance of orders, nor by mere friendliness, nor by a paternalistic openhandedness. A team member is something very different from a cog in a machine. A team member must know from experience that he is expected and encouraged to think about his work and of ways to improve it, make it more productive, make it more pleasant and rewarding. The team member is encouraged to offer suggestions and knows that valuable suggestions will be accepted and will lead to advancement. An organization welded into a team made up of independent team members will be a lively organization; there will be arguments, great differences of opinion; there will probably be violent disagreements; but the team will have vitality and a will to win as an organization. Each team

member, each unit in it, will consider himself important; and he will be important. There are leaders who can bring about this miracle of the creation of a working water works team. The industry could use a great many more. When and as they are found, the entire water works industry will be upgraded.

Conclusion

The water works industry has a record of achievement about which much has been written. The work of the industry has just begun, and more and better men must be found to carry on what has been well started. The Sanitary Engineering Division of the U.S. Public Health Service has recently reported that 108 million people in the United States lack adequate water supplies. It is claimed by the division that 79 million are served by water systems needing improvement and that 2 million live in communities of more than 200 inhabitants without any public water supplies. In rural areas more than 27 million need new or improved water supplies. It is estimated that the nation needs $2,200,000,000 worth of new water works: one-third of that sum is needed for the development of new water supply sources, one-half for distribution facilities, and one-sixth for treatment facilities. If these statements are well-founded, then the work of the water supply industry has only begun. More men must be recruited. Better use must be made of the forces available. Men capable of meeting the new problems must be found and developed and given opportunities. There is much work for the very best. Certain steps must be taken:

1. Foremen and supervisors must be carefully chosen and progressively trained year after year, preferably in state groups. The training must not be limited to filter plant operators, but should also cover the work of all departments, so that each will be headed by a trained leader.

2. The foremen and supervisors should train those who work under their direction and should encourage the best of the group to start going through the training school courses so that new leaders will be developing.

3. There should be short courses—open to those well advanced in position or to graduates of the courses for foremen and supervisors—designed to train men for higher leadership.

4. The higher educational institutions should be provided with opportunities to lay before the students the needs of the water works industry for highly trained technical men and top management, so that the industry can be strengthened each year by ambitious men prepared to make a special contribution to the service.

In all of these steps the A.W.W.A. should take the initiative. When it does, the water works industry will be upgraded.

Washington Suburban Sanitary District

By Harry R. Hall and Harry B. Shaw

A paper presented on July 22, 1947, at the Annual Conference, San Francisco. Prepared by Harry R. Hall, Chief Engr., and Harry B. Shaw, Deputy Chief Engr., Washington Suburban Sanitary Commission, Hyattsville, Md., and presented by the latter.

THE tendency for developments to spring up in suburban areas just beyond the limits of large cities creates a public improvements problem that has given much concern and is becoming increasingly important. These outlying settlements are generally not organized nor individually of sufficient size to finance the cost of improvements easily, so that they either attempt to get along with such temporary makeshift arrangements as are possible within their means or depend upon the nearby city for whatever services it may be willing to provide for them. Neither method is satisfactory nor offers a permanent solution.

The purpose of this paper is to relate the experience with a plan, now in its twenty-ninth year, for providing the essential facilities of water, sewerage, refuse collection and disposal and storm drainage in the large and rapidly growing suburban area in Maryland adjoining the nation's capital. This plan has been neither burdensome nor oppressive to the average property owner, and has provided a stimulus for development in this area that without doubt has been largely responsible for its continuous and orderly expansion.

Origin of Sanitary District

History

This large area, immediately adjacent to Washington, occupied parts of two counties and contained less than 30,000 people, with nine small incorporated towns and five special taxing districts. Five of the municipalities had their own water systems; six had sewerage systems and several land developments had systems of one kind or another, yet only one-fourth of the total population of the area was served by public systems of any kind. The remainder of the inhabitants had to depend on private wells, most of which were polluted, and cesspools or outhouses. The existing public water systems were all inadequate from the standpoints of sufficiency of supply, quality of water or adequacy of fire protection; the sewerage systems were not suitable; and most of the large communities were confronted with the necessity of making large expenditures for water purification or sewage treatment plants. Due to the unincorporated state of many of the communities, the small size of all of them, the prevailing density of population, and the scarcity of available water, the necessary improvement of general water supply and sewerage conditions could not be undertaken economically, if at all, without co-operative effort.

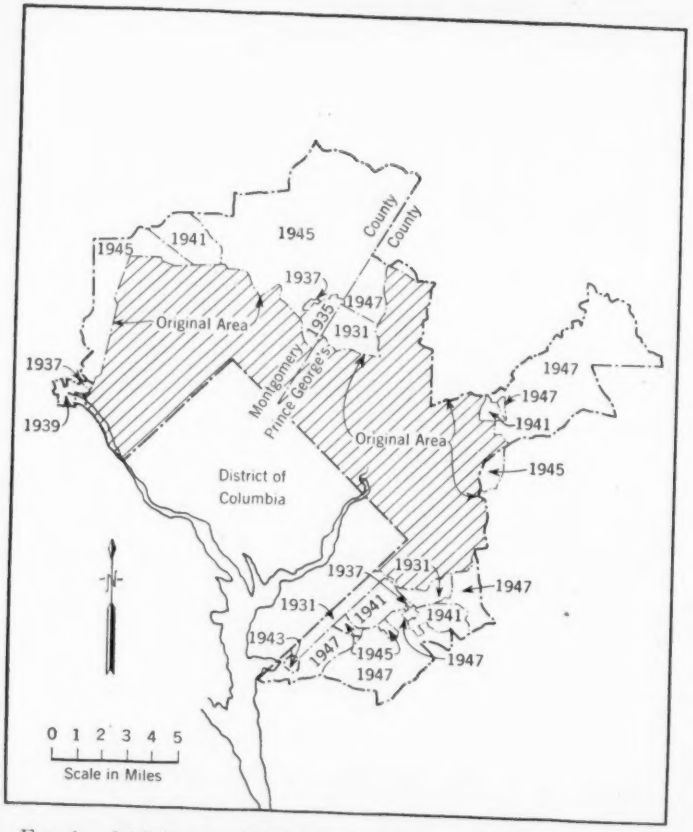


FIG. 1. Additions to Washington Suburban Sanitary District

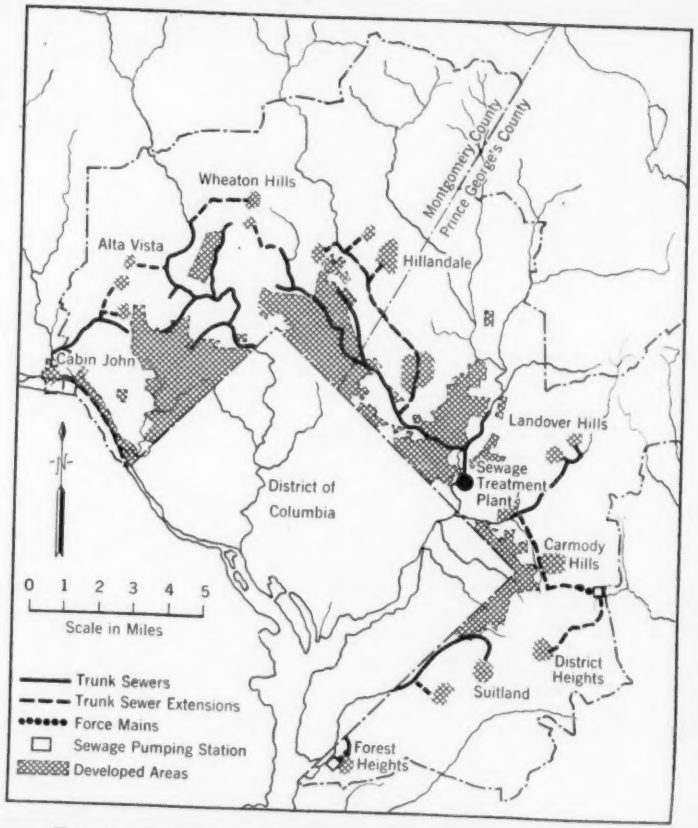


FIG. 2. Development of Areas Within District Boundaries

These were the conditions which, as they saw their section of the state growing in population along with the nation's capital, thoughtful citizens residing in both the counties of Maryland viewed with alarm. In 1911, therefore, they held a meeting with representatives of the Maryland State Department of Health to discuss their common problem. This meeting was the initial step of a process which eventually culminated in the creation of the Washington Suburban Sanitary District in 1918.

The Maryland General Assembly of 1912 passed a resolution forming an unpaid commission, without any appropriation, to make a study of sewerage conditions and to report to the session of 1914. The State Dept. of Health made available the services of its newly created Bureau of Sanitary Engineering, under the direction of the late Robert B. Morse, who became the first Chief Engineer of the sanitary district when it was finally created. Comprehensive reports were prepared and submitted in 1913 and 1918, accompanied by drafts of legislation to make the recommendations effective. No action was taken at the session of 1914, but in 1916 another commission was set up to study both water supply and sewerage conditions, and, on the basis of the ensuing report, the General Assembly of 1918 passed the bill finally establishing the Washington Suburban Sanitary District.

Area of Sanitary District

The sanitary district as organized by the act of 1918 is in effect an overlying muncipality situated partly in Montgomery and partly in Prince George's County and covering practically all the Maryland suburbs of Washington. Its boundary is fixed by law, subject to change only by legislative enactment, and, for the purposes of administration, county and town boundaries are meaningless. Figure 1 shows the present boundary, the extent of additions and the original area of the sanitary district.

A paid commission, known as the Washington Suburban Sanitary Commission, appointed for a 6-year term by the Governor of Maryland, conducts the affairs of the district. The commission is given all the usual powers accorded to municipalities to carry out the functions of water supply, sewerage, storm drainage, and refuse collection and disposal, which it was set up to control. It issues its own bonds as required, without referendum. It prescribes the amount of tax and front-foot benefit charges, which are collected by the two boards of county commissioners, such taxes and assessments covering interest and retirement charges on the bonds issued for general construction purposes. The commission fixes and collects service rates to meet maintenance and operating costs. It has the power of condemnation. Plumbing and gas-fitting installations are under the commission's control and all such work must be done under its supervision and inspection. It has control of the location of underground and overhead structures in the streets, and no such work of any kind can be constructed except after submission of plans to, and receipt of a permit from, the commission. The act permits the commission to enter into agreement with the District of Columbia for the purpose of securing water and disposing of sewage, and acts of Congress allow the sanitary district to participate in the use of these services upon terms prescribed therein.

Fig. 1. Additions to Washington Suburban Sanitary District

Fig. 2. Development of Areas Within District Boundaries

There are two small outlying incorporated communities, Gaithersburg and Washington Grove, entirely separated from the main part of the district, which requested admission in 1924 in order to secure the benefit of water and sewer service under the commission's financial plan. These have separate systems which are not connected to those in the main area and are subject to entirely different rates and assessments.

Funds for carrying on construction work are provided by bonds, of which the total amount of outstanding issues cannot exceed 14 per cent of the value of assessable property in the district. There is no distinction between bonds for water and sewerage work, and funds are allocated to whatever projects of either kind are contemplated at the time of any particular issue. Separate bonds are issued for storm drainage and for incinerator construction. The principal and interest of the bonds are guaranteed by the county commissioners of the two counties, a feature which is believed to strengthen their salability. As all property within the sanitary district is subject to taxation for payment of the bonds, and the district as a whole is liable for their payment, this liability of the counties is only secondary.

At the time of its incorporation, the area embraced by the new sanitary district consisted of 95 square miles, 41 of which were in Montgomery and the remaining 54 in Prince George's County. (In comparison, the District of Columbia has an area of only about 70 square miles.) It had a population of approximately 32,000 and a total assessable basis of $20,000,000. At present, after numerous additions to the district during the past several years, the area covered is 198 square miles, the population is in excess of 200,000 and the assessable basis is $238,000,000.

Bonds issued or assumed by the commission now amount to $29,519,000. Of these, $5,076,000 represent water bonds which, as will be described later, are carried by the charges for water used and, because they are self-liquidating, are not governed by the 14 per cent limitation. There are also $234,000 of self-liquidating incinerator bonds and $1,000,000 in bonds for storm drainage.

Financial Plan

The financial plan for providing water and sewerage service constitutes one of the most interesting features of the sanitary district. When the enabling act was framed, it was realized that construction costs would exceed those in the ordinary city. This condition has been found to be true, for nearly three times as many miles of water mains and sewers have been constructed as the average city uses.

It was necessary, therefore, to devise, if possible, a plan which would not place an undue burden on property within the district. It was felt that such a plan should allocate the expense as nearly as practicable in proportion to the benefit received. Aware of the fact that the most technically accurate scheme would require some modification to satisfy local conditions and prejudices, however, the district authorities felt that any attempt to classify benefits with precision would hardly be necessary.

In this type of suburban area, with so many unoccupied lots and unsubdivided frontages along water and sewer lines, at least in the early years of development, it would be unfair to make the tax rate carry all bond charges because of the great increase

in value accruing to such properties and the relatively small rate increase they would bear. The properties already developed would carry most of the costs under this plan to the extent that an excessive burden would be placed upon them. Yet if the tax rate were to be eliminated, the bond cost must fall entirely on front-foot benefit charges unless part of it were absorbed in rates for service. To impose the entire cost as a front-foot benefit charge only on properties abutting a water main or sewer would prevent the developed lots from bearing their fair share of the benefits accruing to them and no account would be taken of the general benefit to properties adjacent to, but not yet provided with, either kind of service.

After weighing these considerations, it was finally determined to meet the fixed charges on the bonds through a small addition to the tax rate over the entire district and a front-foot benefit charge on properties abutting the water and sewer lines. Maintenance and operating expenses were to be covered by water consumption charges.

Theoretically the tax rate under such a plan should be charged with at least a proportion of the cost of the major works in the systems—such as reservoirs, pumping plants, purification and treatment works, main feeders and collectors—and also much of the expense of general surveys and studies required to provide for future growth of the area. Such projects benefit all property. Residents in outlying areas cannot expect to realize any appreciable advantage to their properties before facilities are made available to them. As a matter of expediency it was deemed advisable to fix the amount to be raised from the tax rate at a low figure.

The greater part of the cost of constructing the systems is carried by front-foot benefit charges on properties abutting the water and sewer lines. This charge is intended to represent the benefit that properties receive from the systems through being accessible to the pipelines, and is applied alike to developed and undeveloped lots. Abutting frontage furnishes a simple and comparatively accurate measure of this benefit.

Property was divided into four classes: business, subdivision, small acreage and agricultural, with the intention that the longer frontages in the two latter classes should bear a lower rate. The legislature, however, attached an amendment exempting agricultural property from assessment until it secured a connection to the systems and then the assessable frontage was limited to 300 ft. The highest base rate is applied to business or industrial properties, with frontage in excess of 200 ft. bearing a lower rate. The base rate on the other three classes is the same, but is less than the business rate. On subdivision property a lower charge is levied for frontages exceeding 150 ft. while on small acreage the same secondary rate as for subdivisions is applied for the first 150 ft. of excess and a still lower rate for all frontage exceeding 300 ft. Agricultural property bears the full rate when connected, although the full frontage allowed under the law has never been assessed. Classifications are varied from time to time as the uses of properties change. The law provides that assessments may be paid up at any time, but the number completely paid is negligible.

The frequent practice of applying front-foot benefit charges for public

improvement to be payable either in a lump sum or over a relatively short period of years, it was believed, would cause an excessive burden to fall on many properties, because of the long frontages and large amounts of undeveloped property which would abut water and sewer lines. It was, therefore, determined to spread the benefit charge over the life of long-term bonds, which originally were 50-year sinking fund bonds, but later were changed to 40-year serials to comply with a more recent state law in Maryland. The annual requirements of long-term bonds are small, and the burden on long frontages is not excessive. This feature has done more than anything else to permit the construction of water and sewerage systems in a sparsely settled but large suburban area with little if any greater individual expense than in more congested centers of population. It is the main reason for the financial practicability of such a large project in an area of this kind.

Administrative Problems

Personnel

The commission started its operations just after the close of World War I, when returning veterans from the armed services were seeking employment, so it was possible to build up its engineering and other personnel rapidly to the requirements of the anticipated work. As it was embarking on a new venture with an entirely untried plan, however, it felt the necessity of proceeding cautiously in committing itself to heavy expenditures for personnel. Furthermore, although its salary scale compared favorably with those in effect in similar types of municipal organizations, it eventually found itself in competition with such features of federal government employment as civil service, retirement and vacation and sick leave benefits. In 1941, therefore, a retirement system handled by an insurance company was installed which was effective for all except day-labor employees. This policy has just been cancelled and on July 1, 1947, all employees were placed under the Maryland State retirement system, which gives recognition to the prior service of older employees—a feature that was not considered in the original policy. At the 1947 session of the Maryland General Assembly, a merit system bill was passed, effective June 1, 1947, which embraces all employees in the service on that date and gives more liberal vacation and sick-leave allowances. This system will be administered under the Commissioner of State Employment and Registration of Maryland. Thus it is believed that one of the growing difficulties of the commission will be overcome, for it now can offer better inducements to new employees and more reason for the older employees to remain in its service. Already these benefits have served as deterrents to some who might otherwise have resigned to take higher paying positions, and others, who already had left, have sought reinstatement.

Co-operation With Other Agencies

As the sanitary district has an overlying jurisdiction embracing many municipalities, special taxing areas and some territory under county government only, with town, county, state and even federal agencies concerned with its operations, the necessity for extensive co-operation in its activities is quite obvious. It is not managed

like a municipality, which has control of all the usual municipal functions.

It must secure permits from the State Department of Health for all construction work. The State Forester requires that construction work in all public roads be subject to review by his office for the protection of roadside trees, and the commission employs a full-time forestry man who is under his direction.

The commission works in close cooperation with the Maryland-National Capital Park and Planning Commission, the agency which has authority over planning, subdivision layout, parks, zoning, street grade establishments and other related matters in the area generally served by the sanitary commission.

State, county and town highways and streets have to be entered for installation of water and sewer lines, house connections and storm drains, and the commission is charged with the responsibility for their proper restoration. The commission also co-operates with state roads officials on the location and repairs to paving of state highways.

The neighboring District of Columbia provides another agency for close co-operative effort, as the commission maintains emergency connections to its water system, and a reciprocal arrangement for disposal of the sewage through the system of one or the other on the basis of a contractual agreement between the two agencies provides the incentive for excellent working relations.

The proximity of the sanitary district to Washington naturally places the commission in closer contact with federal agencies than is usual for such bodies. The tendency of the federal government, displayed just before the start of the last war, to seek sites for new buildings beyond the confines of the District of Columbia, has resulted in the acquisition of large areas of land in Maryland and the construction of such buildings as the National Institute of Health, Army Map Service, Naval Hospital, Walter Reed Hospital Annex, Beltsville Research Center, Census Building, Glenn Dale Sanatoria, the large Greenbelt development of depression days and many war housing projects. These have required the commission to deal with such federal agencies as the Departments of War and the Navy, and bureaus in charge of Public Roads, Public Buildings and Grounds and any others involved in government construction projects.

The commission is favored in this proximity to the seat of the national government because it is able to make frequent personal contacts with those agencies that are in a position to give it assistance in its work, such as the Weather Bureau, U.S. Geological Survey and the Coast and Geodetic Survey.

Subdivisions and Street Grades

In the early days of its operation the commission encountered problems in construction which definitely tended to increase its costs. Its first construction projects naturally involved the extension of water and sewer services to houses in established communities where streets already were graded and paved to some extent or perhaps were not even graded at all. It was frequently deemed necessary to establish new grades where the grades were obviously improper, in the hope that they would be adopted by someone (no agency had control over them at that time) and become permanent, and to lay the water mains in accordance

therewith. Often pipes were laid as deep as 10 ft., in order to avoid the necessity of lowering them again. Furthermore, there was no control over street planning, and each developer laid out streets to serve the purposes of his own property, without regard to adjacent tracts, so that there was lack of both continuity and a future plan, which seriously affected proper designing of the water and sewer systems.

As a result of this confusion, in 1922 the General Assembly gave the commission authority over street planning and grade establishments. No subdivision plats could be placed on record or streets graded without previously obtaining the approval of the commission. This materially improved the situation, for the commission refused to extend water and sewer mains in new subdivisions until streets were graded in accordance with the approved grades. In 1927 an act of the General Assembly created the Maryland-National Capital Park and Planning Commission, to which was delegated the authority over subdivision layout and street grade establishment previously held by the sanitary commission, as well as other functions relating to planning, parks and zoning. This commission refers to the sanitary group all street layouts and grades before giving its final approval, to insure that they meet the requirements of water, sewerage and storm drainage design.

Public Relations

The commission has experienced other difficulties, as would be supposed, in launching a program of such magnitude, for there has been much popular misunderstanding of its authority. Charges of autocracy, secrecy, lack of sufficient check to its authority, of imposing high rates and of creating a burdensome public debt have been made. Much of this feeling has been overcome, but there still remains a misunderstanding in the minds of many about the commission's status, some of which may be due to the commission's failure to take the public completely into its confidence by giving the fullest publicity to its acts. Even today the belief that the commission is a private corporation exists, particularly among more recent residents in the area, to whom such an organization is unfamiliar. After 28 years of operation, the commission has finally concluded that its interests require a better effort to keep the public informed and has appointed a trained newspaper man as Director of Public Relations, to provide the proper means of disseminating information about its operations and policies.

Additions to District

The rapidly expanding area of the sanitary district has introduced problems in extension of its facilities—the only reason for areas seeking to be brought into the district is the desire for service—and this, of course, has required constant planning ahead and construction of additions to the water and sewer systems.

Developers tend to attempt operations at remote locations far beyond existing sewers (Fig. 2), because the land is cheaper than where service is available, and then expect the commission, at public expense, to provide long extensions for them to make the projects possible. This situation has given much concern. The commission has finally been obliged to refuse extensions to far-flung areas, even though the promoters of such projects bear part of

the cost, because the effort, time and cost required can be devoted to providing the service more effectively to a greater number of houses, without excessive amounts of construction.

Expanding National Capital

The growth of the sanitary district is related to its adjacent city, Washington, D.C., the population of which has continued to climb with the increasing business of the nation and its growing importance in world affairs. After World War I, the periods of depression, recovery, preparation for and duration of World War II, and its postwar readjustments—all have brought more people to Washington and have had their effects upon the commission's operations. The area has continued to develop, along with considerable additions; the population has increased; and there has been no cessation of activity. In fact, the only decline in activity was during the major depression in the early 1930's. This gradual growth, accompanied by accelerated activity at times, has required continuous planning for future requirements. There have been times when development of the facilities has been very little in advance of the current demands, particularly these days, when the great increase in the demand for housing is severely pressing the ability of the commission's personnel to meet the requirements.

Other Utilities

It was realized when the commission was organized that there would have to be some orderly method of allocating space in the streets and highways for underground structures, because of the multiplicity of municipalities and other governmental units, with no single agency empowered to provide this function. The commission's enabling act contained a provision giving it this authority, and no underground structures of any kind may be laid in public ways in the sanitary district until after it has approved the plans and issued a permit. Later the power was extended to cover all pole lines, and at the 1947 session of the General Assembly a bill was introduced increasing its authority to require the placing of overhead wires underground in thickly-settled areas wherever the commission deemed it desirable. This bill failed of passage.

Operation of the Financial Plan

Since its creation the commission has sold or assumed 56 issues of general water and sewer construction bonds amounting to $23,916,100. This amount does not include $5,500,000 of water bonds used solely for major projects in the water supply development. Bonds amounting to $241,100 have been assumed from the municipalities whose systems were acquired. Figure 3 shows the trend of bond issues, population and house water connections installed by the commission from the time of its organization to the end of 1946. The effects of the depression and later recovery, the war, and the present postwar period of renewed activity in building are quite clearly indicated by the slope of the curves, particularly of the general bond issues. At present there are outstanding $23,209,000 in general construction bonds and $5,076,000 in water bonds.

This financial program has not been without its difficulties, for the commission found that its original front-foot benefit charges were too low, and, in order to avoid establishing too high a

rate on later construction, had the clause prohibiting any increase in assessment stricken from the law. It then raised the lower assessments levied in earlier years in an effort to distribute the costs more equitably. The Maryland Public Service Commission, when appealed to, ruled that the new charges were not unreasonable but that it could not pass upon their legality. The county court, to which the case was next presented, decided the commission was without power to increase a front-foot benefit charge when once levied.

At the next session of the General Assembly an amendment to the law was passed making the increased rates effective. This was attacked in the county court, but was finally upheld by the Court of Appeals of Maryland in 1927, after a decision in the lower court unfavorable to the commission, and, as the Supreme Court of the United States refused to review the case, the increased rates became effective. To secure the passage of the amendment, however, it was necessary for the commission to consent to reinsertion in the law of the provision prohibiting any increase in an assessment once levied.

It was the original intention of the commission to have the water rates cover only the maintenance and operating expenses of the water and sewerage systems, but the desire to keep the general tax rate at a lower figure has compelled it to secure special legislative acts enabling it to pay for construction of reservoirs, purification works, pumping stations and main supply lines through the water rates. This is not in accord with the fundamental theory upon which the financial plan was based, but it appeared to be the best solution of a financial problem brought up by unanticipated costs during the period when the commission was working out its previously untried plan.

The financial program finally employed by the commission may not fully meet in all respects the original theoretical conception of apportionment of costs, but it is believed to be sufficiently sound, and it preserves the equities for all practical purposes. Under the plan, property not accessible to a water main or sewer is subject to very little annual expense. Undeveloped land along a pipeline bears a burden which is somewhat larger and is sufficient to stimulate building. Developed lots of ordinary size, although incurring considerably larger payments, on the average, still are put to an annual expense amounting only to about three dollars per month for complete water and sewerage service.

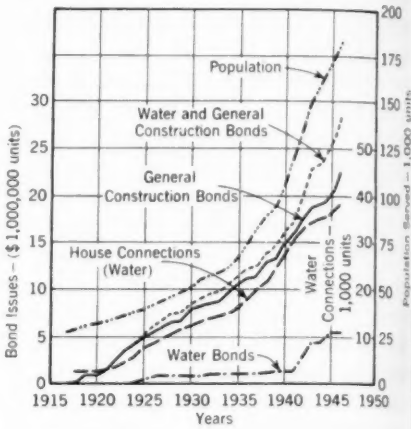


FIG. 3. Relation of Bond Issues to Population and Services

The water rates include an annual ready-to-serve charge varying from $2.00 for a ¾-in. meter to $300 for an 8-in. meter, and a consumption rate varying from 22¢ per 1,000 gal. for the

first 50,000 gal. used semi-annually to 15¢ per 1,000 gal. for all water consumed in excess of 2.5 mil.gal. monthly. Public fire hydrant service and water for municipal uses are furnished without charge.

Table 1 shows the cost to an average property for complete water and sewer service under this plan and typical examples of the manner in which the charges apply to the three types of property mentioned above. There is considered: (1) a property assessed at $6,000, not accessible to water main or sewer; (2) an undeveloped lot, assessed at $1,000, with a 60-ft. frontage on a street in which there is a water main and sewer; and (3) a building and 60-ft. lot assessed at $6,000, the property using 60,000 gal. of water annually through a ⅝-in. meter.

It is evident that the cost to the inaccessible property is slight; that the undeveloped accessible lot is not unreasonably burdened, but is provided with the incentive for development; and that an average residence obtains all the advantages of complete water and sewer service for a moderate cost. The front-foot rates given are the maximum existing for subdivision property. Many of the early rates were considerably less and some are still substantially so, even since the advance was made effective.

Changes have been made in some of the rates, although the front-foot charge has not been altered since the final court decree in 1927. Rates for water consumption have not been increased since 1925, except for a recent raise in the lower rates in the sliding scale—which affects only the large customers—advancing the minimum from 10¢ to 15¢ per 1,000 gal. On the other hand, the readiness-to-serve charge has been reduced from $4.00 to $2.00 on a ⅝-in. meter and has also been reduced on larger sizes. The portion of the tax rate applied to water and sewer construction has been reduced from 7¢ to 6¢ per $100 of assessed valuation, and the difference between this figure and the 10¢ per $100 now charged, or 4¢, is used to finance storm drainage construction.

Under the financial program, the commission has been able to keep pace with the growth of the sanitary district in the development of its water and sewerage service. Over 1,100 miles of water mains and sewers have been installed, and two dams, four water filtration plants, several water pumping sta-

TABLE 1

Typical Annual Service Costs to Three Properties

Charges	Properties		
	1	2	3
General tax (6¢ per $100)	$3.60	$0.60	$3.60
Front-foot benefit charge (14¢ water, 14¢ sewer)	—	16.80	16.80
Ready-to-serve charge	—	—	2.00
Water consumption charge (22¢ per 1,000 gal.)	—	—	13.20
TOTAL ANNUAL EXPENSE	$3.60	$17.40	$35.60

tions, supply lines, trunk water mains, elevated storage structures, trunk sewers, sewage pumping stations and sewage treatment works have been constructed without increasing charges, except for those increases made necessary as a result of early trials before actual costs became ascertainable. Furthermore, estimates recently made in a determination of construction and operating costs and anticipated revenues through 1950, as nearly as these can be predicted, indicate that at least until that time the present rates will carry all construction necessary without any increase.

Much, of course, depends on the continued attractiveness of the commission's bonds to the investor and their ready salability at satisfactory interest rates. Undoubtedly much of the successful operation of this plan is due to the strategic location of the sanitary district in the suburbs of the national capital, which has assured from the outset a continuously increasing population along with the growth of the business of government and the importance of Washington in world affairs. This has provided the impetus for building which has so increased the assessable value of the area and the returns to the commission from the use of its facilities that it has always been able to show surpluses in its operations after its costs were once definitely determined and its charges adjusted accordingly. One exception is the charge for house connections, which will have to be increased.

Suggested Revisions

The plan of financing the commission's activities has been followed, almost entirely or in part, by other sanitary districts more recently established. It is not suggested that the plan is applicable to all sanitary districts, and time has disclosed, at least in the authors' opinion, some improvement in, and modification of, the methods of financing which could be advantageously adopted. Some of these may be described.

Under the present system, front-foot benefit charges are not levied against property used for agricultural purposes. The exemption of agricultural property was not in accordance with the commission's original plan, but was the result of an amendment attached to the bill by the 1918 General Assembly, apparently on the theory that such properties paid for such enhancement of value in the *ad valorem* tax and should not be further burdened. Theoretically, however, this tax is supposed to defray the cost of trunk sewer and feeder main construction, and is paid by all classes of property within the sanitary district. Actually, the value of any property within the bounds of the sanitary district, located as it is, adjacent to the national capital, is greatly increased by abutting water and sewer lines located along its frontage. Good roads, availability of transportation, the "back-to-the-land" idea, healthy moral and physical environment, school buses, the atomic bomb, the growth of the shopping center plan, reduction in fire insurance rates—all make this so. Therefore, the authors feel that a low front-foot benefit charge should be levied against agricultural property when abutting facilities are installed. Conditions change and the commission's practice must keep abreast of them.

The building up of the area close to the District of Columbia and the resulting tendency to develop where land values are lower, augmented by the factors previously mentioned, have necessitated the construction of facilities to eliminate the pollution of water-

courses and supply both the close and outlying developments to such a degree that the *ad valorem* tax originally devised to pay for them is now inadequate. The *ad valorem* tax should therefore be increased, to carry the cost of the trunk sewers and feeder mains serving the so-called close areas, with a corresponding decrease in front-foot benefit charges; and these front-foot charges should be increased for the outlying areas. This latter reasoning was recognized when the 1947 session of the General Assembly of Maryland gave the commission authority to fix charges in two predominantly rural outlying areas, which it brought into the sanitary district, without reference to charges in the rest of the district.

Under the present plan of financing, the cost of sewage disposal is paid for out of water receipts. This is not desirable from the commission's standpoint, nor in the opinion of the authors. The ultimate plan of the commission is to dispose of the sewage from the sanitary district into the District of Columbia system whenever practicable. It is believed desirable, therefore, to separate the resulting sewage disposal costs from those of supplying water—a function performed entirely by the commission. Also, in outlying areas where sewerage service will be supplied to some places and not to others, it would be obviously unfair not to charge the areas so served more for the additional service.

Water and Sewerage Systems

House Connections

The commission constructs and maintains all water and sewer connections as far as the property line, making the same flat charge of $42.50 for a ¾-in. water service and a 6-in. sewer connection regardless of length or difficulty of construction. Rates for larger services vary with the size of the connection. Actually water connections over 2 in. and sewer connections over 6 in. in size are constructed at cost. Meters are placed on all water services in outside settings, generally near the property line. The cost of the setting, but not of the meter, is included in the house connection charge. The disparity between charges and costs has increased very considerably with the adoption of wider streets and more expensive types of paving, and this disparity, together with advancing prices, has caused the average cost of connections to mount to such an extent that there is now a considerable deficit which will require a substantial increase in the charge. In 1946 the average cost of all water and sewer connections installed was $74.58 and $138.90, respectively.

Double connections, that is, one connection of both water and sewer lines to serve two houses, are used wherever possible. As the commission installs and maintains all connections in public ways, such a plan is possible, for there can be no conflict in responsibility for maintenance. Double connections are not used for water services larger than ¾-in., nor on sewer services requiring more than 6-in. pipe. They are not feasible on wide lots of more than, say, 70-ft. frontage, because of the long runs that the property owner would be required to build, nor can they be used for sewers on steep grades due to the wide differences in elevation in adjoining house basements. The experience has been that nearly two out of

every three houses can be served by double connections.

Water and Sewerage Lines

When the commission was organized there were in existence about 17 water and sewerage systems, with approximately 51 and 55 miles, respectively, of pipelines. They included five municipally owned systems, and the remainder were either under the control of subdivision developers or were operated by the residents of the communities. Most of the water systems had drilled wells of limited capacity, low elevated storage tanks (except in two systems, where no storage whatever was provided), and the mains generally were only large enough to provide domestic service, with little or no fire protection. Only a few were of any value to the commission for incorporation into its system. There were about 1,600 properties connected.

At the end of 1946 the commission's water and sewerage systems consisted of 606 and 495 miles, respectively, of pipelines, with 38,687 water and 32,688 sewer connections. As many as 80 miles of lines have been constructed in one year. Figure 4 shows the progress of additions to the systems and of connections to houses. The effects of the depression in the early 1930's, the later recovery, the demand for facilities for war housing and the effect of the last years of the war, are plainly indicated. Attention is called to the sharp increase following the end of the World War II.

The materials used are those generally standard in water and sewerage works. Cast-iron pipe is used in the water distribution system up to and including 24-in. sizes, with sulfur joint compound backed up by braided hemp. Advantage was taken of the introduction of centrifugally cast pipe, and the commission was one of its early large users. Difficulty has been experienced with one of the types of centrifugal pipe during cold weather, as circumferential breaks occur. In one winter 33 breaks of this kind occurred. Every winter at least a few are experienced. The exact cause of the trouble has not been ascertained, and the manufacturers have not yet been able to give a satisfactory explanation. It has not occurred with sand-cast pipe. The breaks have been so frequent that they cannot be attributed to improper bedding of the pipe. The 30-in. pipe is prestressed

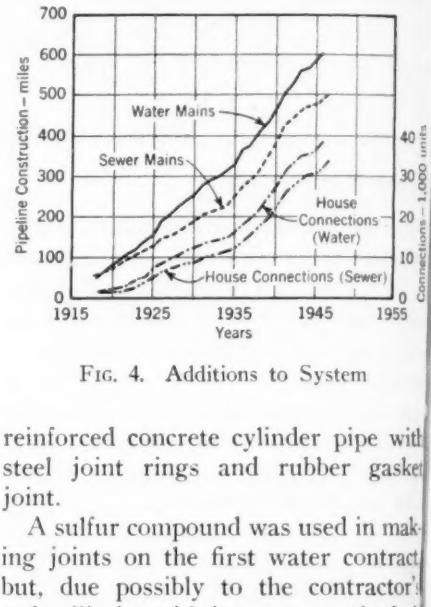


FIG. 4. Additions to System

reinforced concrete cylinder pipe with steel joint rings and rubber gasket joint.

A sulfur compound was used in making joints on the first water contract, but, due possibly to the contractor's unfamiliarity with its use or to the lack of pressure, which was not put on the line until several months after its completion, the line leaked so badly that most of the joints had to be repoured with lead. As a result, lead was used for several years thereafter. The success in other places with the use of compound finally led to another trial and ever since that time sulfur joint

compounds have been used, except in special joints where initial water-tightness is essential, in which lead is substituted.

The commission has in its water system about 7.5 miles of wood-stave pipe, which was acquired in the purchase of the Mt. Rainier municipal system. This pipe was laid in 1918 and has been in use ever since. After its acquisition the pressure was raised, and some of it now carries as much as 100 psi. Leaks develop from time to time, and special clamps and sleeves have been devised to take care of them; but as yet no extensive breaks have occurred to create any serious situation. The commission is now making plans to replace all the wood pipe as soon as possible.

In the sewerage system, vitrified clay pipe with deep and wide sockets has generally been used in sizes up to and including 24 in. in diameter. In larger sizes, cast iron, both coal-tar enamel and cement-lined, and reinforced concrete have been used. Satisfactory use of reinforced concrete pipe in sizes down to 15 in. has been experienced. The commission has constructed several miles of 24- to 42-in. sewers of centrifugally cast reinforced concrete pipe. This type of pipe, when properly made, gives a smooth interior surface and is superior to that manufactured by other methods. In the past two years all sewer construction has been of concrete pipe in all sizes, using plain concrete for diameters up to and including 12 in. and reinforced concrete for larger sizes. This change was occasioned by the condition of the vitrified pipe industry and its apparent inability to furnish the kind of pipe required by the commission. All vitrified pipe used in recent years has been of the extra-strength class, and concrete pipe of equivalent strength is now called for.

Development of Water System

The commission in its early consideration of the water supply problem anticipated securing water from the system of the District of Columbia. On making application, however, it was informed that, because of the demands on that system following World War I, no water could be spared for the Maryland area. It was necessary, therefore, for the commission to lay out its own system and to develop a separate source of supply. The sources supplying some of the larger existing systems were reviewed, and it was finally determined to utilize them where possible and augment them so far as could be done until a permanent supply could be established. The immediate expenditure for a new source of supply was neither financially feasible at the outset nor was it deemed necessary. Figure 5 shows the locations of the principal systems acquired and the extent of the area now served with water.

The commission acquired the municipal systems of Hyattsville, Takoma Park, Kensington and Mt. Rainier, Md., and the larger real estate systems of Chevy Chase, Bradley Hills and Edgemoor, and used them as the nucleus for extension into outlying areas as far as practicable. Other smaller systems were either acquired and used for a time, later to be abandoned, or were completely ignored. The first requirement was to provide service to existing houses, where water supply conditions were acute, or to new developments unable to secure adequate supplies.

The first attempt at development of any new water supply source was the

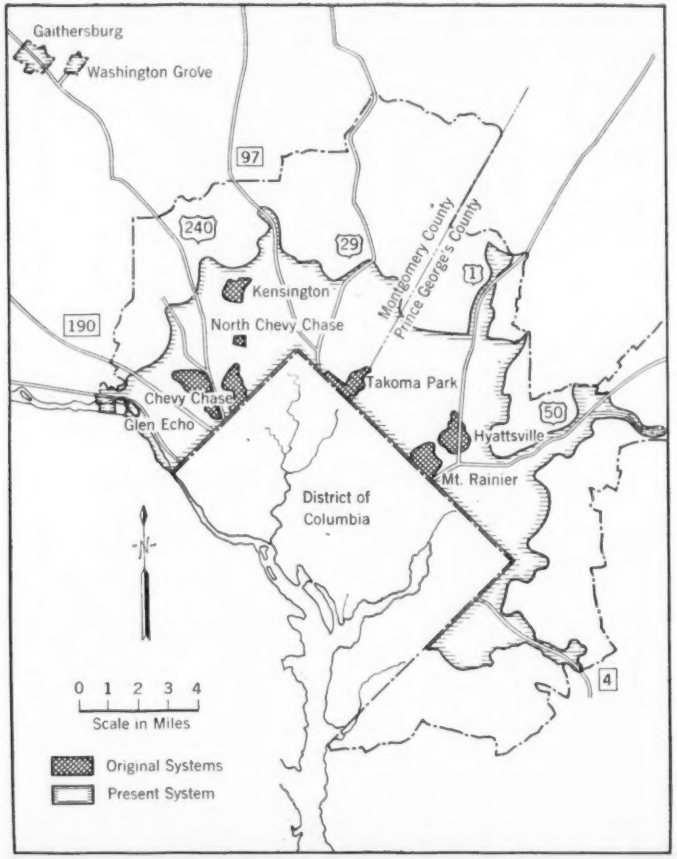


FIG. 5. Original and Present Water Systems

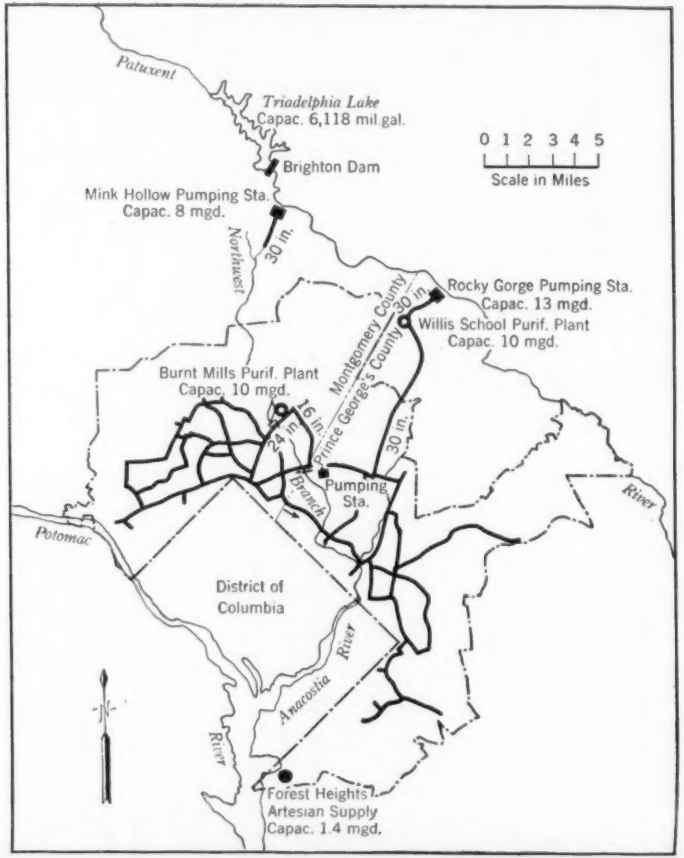


FIG. 6. District Water Works

construction in 1920, in Hyattsville, of a 1-mgd. rapid sand filter plant which secured water from the Northwest Branch of the Anacostia River, a stream still used as one of the sources of supply. This was the beginning of the water supply development. A system of wells appurtenant to the acquired Chevy Chase system served that area until 1922, and a rapid sand filter plant acquired from the town of Takoma Park was used until 1930, with additions to increase its capacity so that it could provide service to a considerably larger area. In 1924, at the site of the present Burnt Mills plant on Northwest Branch, the first major development of this stream was begun, consisting of a small stone intake dam; a steel coagulating basin; four wooden filters equipped with rakes for sand agitation, housed in a galvanized iron building, with an initial capacity of 2.5 mgd.; a steel filtered water reservoir; and the necessary low- and high-lift pumps. In 1930 a small Ambursen dam replaced the stone intake structure. An additional capacity of 1.3 mgd. was obtained in 1926 from two open steel filters with wooden slat bottoms and a steel coagulating basin. The material from the first plant, except the building and pumps, was purchased from a war industrial plant abandoned after World War I. This installation at Burnt Mills, although definitely intended as a temporary measure, actually served until 1936, when the present permanent Burnt Mills plant was finally completed. Thereafter all other sources of supply were abandoned.

The distribution system itself was gradually developed as the commission sought to extend service to the many communities as rapidly as possible. Not only were the service mains laid in the areas of development, but cross-country lines were extended to connect the various parts of the system with one another over the vast expanse of territory making up the sanitary district, so that all could be served eventually by a single source of supply. This plan introduced problems of design because the lengths of trunk lines involved would have entailed heavy costs, resulting in disproportionately large expenditures during the early days. Smaller sizes of arterial lines, therefore, were adopted to fit in with a general plan of larger trunk mains that would be required in the future. Many of these larger lines have since been built.

The system, shown in Fig. 6, is generally divided into two main pressure zones. The Montgomery County section is the high-service area, with a lower zone along the Potomac River, fed through reducing valves. The Prince George's County section is at a lower elevation and, until the introduction of the new Patuxent River supply, to be described later, was served entirely from the Burnt Mills plant and the Montgomery County system through reducing valves. There is a rapidly growing area in this county at an elevation higher than the general county service, for which the use of a booster pumping station is required.

The commission maintains eight emergency connections to the Washington water system through which water can be pumped or drawn by gravity to furnish approximately 8 mgd., provided the Washington supply is not jeopardized. These are essentially emergency connections.

The Burnt Mills plant furnished all water used in the sanitary district until 1939, except during summer periods and times of low stream flow, when

Fig. 5. Original and Present Water Systems

Fig. 6. District Water Works

the Washington connections were drawn from to make up the deficiency. During that year the first step was started on the development of the Patuxent River for an additional water supply by the construction of a pumping station at Mink Hollow, near Ashton, and a 30-in. steel pipeline, through which 13 mgd. can be pumped, was extended across the divide to supply the additional water necessary to augment the flow from the 27 square miles of watershed on Northwest Branch. Late in 1941 work was started on the main Patuxent River development. This included a dam near Brighton, about 2.5 miles above Mink Hollow; an intake on the river and a pumping station of 13-mgd. capacity at Rocky Gorge, about one mile above Laurel in Prince George's County and 13 miles below the dam; a force main to a 10-mgd. steel Morse type rapid sand filter plant, about 3 miles west of Laurel on the Laurel-Burtonsville Road; and an 8-mile, 30-in. gravity supply line to Prince George's County. This project was put in operation in 1944.

The present supply consists of two 10-mgd. rapid sand filter plants, one on Northwest Branch, which now serves Montgomery County, and the other on the Patuxent River serving Prince George's County. Interchange of water between the two parts of the system may be effected by feeding through the reducing valves or pumping back through a booster pumping station. The Burnt Mills plant takes water from Northwest Branch, with the stream flow supplemented when necessary by pumping over from the Patuxent River at Mink Hollow; and the new Willis School plant secures its supply directly from the Patuxent at Rocky Gorge. The Brighton dam regulates the stream flow.

The new Willis School plant, including the head house, is constructed entirely of steel. The six filters, chemical storage, chemical feeders and all the operating mechanisms, piping and valves are contained within a circular covered structure that is surrounded by the open coagulating basin, which provides a 4-hour detention period. At one end of this assembly is placed the head house containing, when completed, chemical storage, chemical feed machines, lobby, office, complete chemical and bacteriological laboratory and mechanical equipment, surmounted by a 140,000-gal. wash water tank. There is a separate 2-mil.gal. covered steel filtered water reservoir located behind the filter assembly.

This development was expected to serve until sometime after 1955, based upon population estimates and consumption requirements made in the period just before the war. The picture has changed completely; and water consumption in 1946, which had been predicted as 11.3 mgd., was actually 14.8 mgd. Revised estimates indicate that the next step in the development will have to be advanced by not less than five years, and it probably should be in actual operation by 1950, when the average consumption may soar close to 20 mgd. This step (Fig. 7), on which actual surveys already are under way, will include: the construction of another dam, approximately 110 ft. high on the Patuxent River, just above the Rocky Gorge pumping station, to increase the dry weather yield by something over 25 mgd.; a hydroelectric plant to provide power for operating the pumping station; increase in pumping station capacity; and a 10-mgd. addition to the Willis School filter plant, including a pumping station and 42-in. force main

approximately 10 miles long to the Montgomery County service, to meet the increased demands in the area which the present Burnt Mills plant will be unable to serve. Ultimately the Burnt Mills plant will be abandoned, as its watershed is becoming populated by development, and it is anticipated that the entire supply will eventually be procured through Willis School, which can be increased to a capacity of at least 40 mgd. Along with this increase in water supply will be constructed such additional trunk lines in the general system as are required to maintain adequate flows throughout and also more storage facilities. Plans are now under consideration for the erection of a 15-mil.gal. steel storage tank on the Montgomery service.

The Middle and Little Patuxent Rivers and Seneca Creek present the next possibility as sources of supply. In combination with the Patuxent River they can be depended upon to yield about 150 mgd. daily, which would serve a population of more than a million people.

Ground Water Supply

About 1943 a developer built a small community of about 100 houses just over the District of Columbia line off Livingston Road. Shortly thereafter the federal government began construction of a highway between Washington and the Naval Powder Factory at Indian Head, Md., on the Potomac River. As this highway will provide direct and close access to downtown Washington it became evident that this new road would bring about the early development of the area that it traversed. The initial real estate development also was expanding, and therefore needed more water. It was without sewerage or adequate fire protection.

When the commission was requested to service the development, it asked the Washington authorities if they could supply the area with water at the district line, as it had no facilities of its own closer than about five miles. The Washington system was severely taxed by war demands in this part of the District of Columbia, and the authorities had to decline to furnish the requested water supply. If the existing development and the development of the general area were not to be retarded, something had to be done.

A study of the geology of the section and of existing well supplies led the commission to believe that a potable supply of ground water in considerable volume could possibly be secured. An economic study revealed that such a project would be financially sound if the indicated supply was obtained. Test wells substantiated the original estimates closely. As a result of the test hole showings, two gravel-packed wells a quarter mile apart were drilled to bedrock (about 600 ft.) and produced on a combined test about 925 gpm. of water of fine quality. A pumping station was built over each well, the water from which is pumped to a receiving reservoir adjacent to one of the stations, which also contains the high-lift pumps, and the water distribution system, including a 300,000-gal. elevated tank, was constructed in the community.

The results with the gravel-packed wells indicate that it will be feasible and economical to supply the area in Maryland south of Washington for a considerable distance along the river up to elevation 200 with ground water. Other wells will be drilled along the base of the river escarpment as needed,

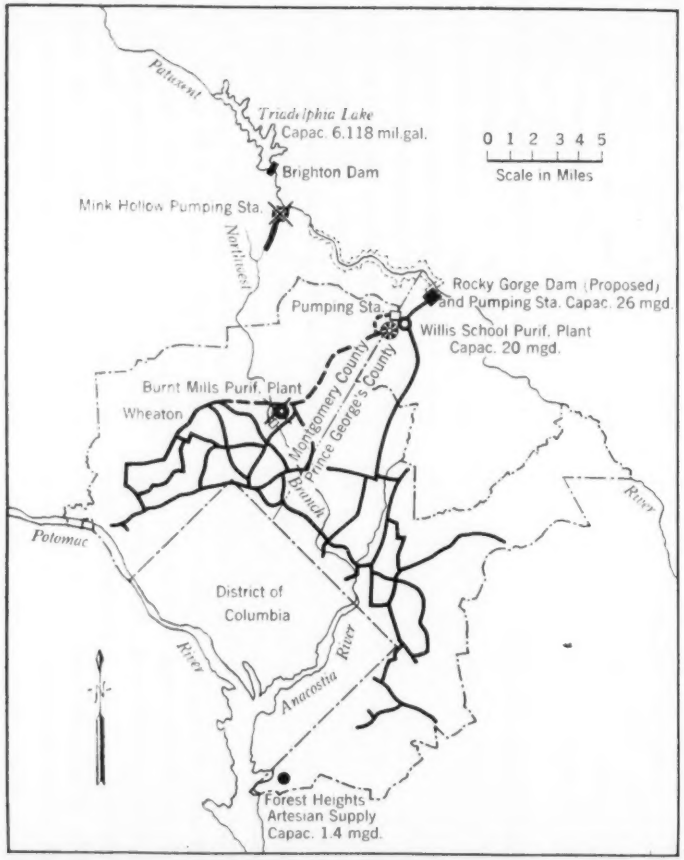


FIG. 7. Water Development Planned

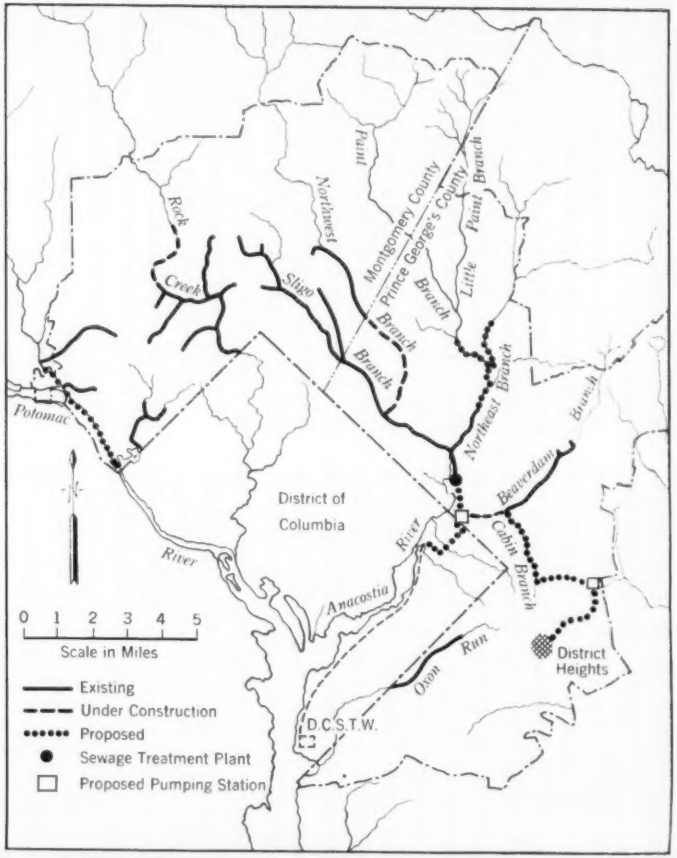


FIG. 8. Trunk Sewer Plan

and will be pumped into the receiving reservoir.

The importance of the ground water supply lies not merely in its economy but also in the fact that it permits the early development of this remotely located section.

Development of Sewerage System

When the commission commenced its operations, one of the important problems facing it was a determination of the manner in which it should proceed in the development of the sewerage system. All the major stream valleys drain through the District of Columbia and, of course, it was desired as far as possible to protect these streams from pollution, but the Washington system at no place had been extended to the district line to provide outlets for Maryland sewers. The commission was confronted with two possibilities. It could start at the district line, build treatment works and commence the construction of trunk sewers upstream to the several communities—a procedure which would have involved it immediately in the most expensive construction costs of all—or it could start laying sewers in the communities themselves—a choice which would provide immediate relief from overflowing cesspools and septic tanks—and discharge the sewage into the nearest watercourses, well removed from houses, where it could be better controlled, and then gradually extend the trunk sewers downstream to ultimate disposal as its funds could be made available.

The commission was starting a new venture. It realized that the requirements for sewerage service would be greater than in the average city and that there was a limit to the funds available for this purpose. It was not inconceivable that, if it followed the first plan, it would find itself with treatment works and trunk sewers constructed and no funds left for lateral sewers to serve houses. This was particularly true under its financial plan, for these major works do not yield assessment, and the only source of revenue would have been a small *ad valorem* tax. After careful consideration, the commission decided to adopt the second plan and attempt to give service to houses first.

The wisdom of this decision was affirmed as its work progressed, for the real need of relieving sanitary conditions was covered, service was immediately available for new housing, and thus an impetus was provided for development of the area. Also, revenue from front-foot assessments became payable at once, and enabled the commission to start off on a firm basis financially.

The municipal sewerage systems of Hyattsville, Takoma Park, Kensington and Mt. Rainier, and the real estate development systems in Chevy Chase, Edgemoor and a few other subdivisions, which were adequate in design, were acquired by the commission and extended where possible to provide service for adjacent areas. As revenue increased and further funds became available, the sewer outlets were gradually extended downstream, and each year trunk sewers were carried further. As the sanitary district increased in wealth, therefore, its ability to pay for the greater costs of these trunk lines, as they were extended further downstream, also grew. It has carried on this policy from year to year, until at the present time the sewage from 85 per cent of the sewered population is given some form of treatment. In the valleys of Little Falls Branch, Rock

Fig. 7. Water Development Planned

Fig. 8. Trunk Sewer Plan

Creek and several other smaller areas, the sanitary district sewers are connected to the Washington system. A large part of the Anacostia River valley is served by treatment works providing primary treatment. In a few other regions small temporary treatment plants are used, and sewage from the remainder of the system is discharged directly into streams. The general trunk sewer plan is shown in Fig. 8.

The commission's program of trunk sewer construction was of necessity deferred during the war, and it now finds itself faced with an expenditure of several million dollars to meet the plans of pollution elimination that it has set out to complete. This program cannot all be accomplished at once, and it will have to be distributed over several years; but the commission will eventually begin construction of all projects, and it confidently anticipates that, within the next few years, the streams running through the district will be free from pollution.

Other Functions of Commission

Although the commission's primary job has been to furnish water and sewerage service to the Washington metropolitan area in Maryland, it provides the following public services as well: refuse collection and disposal, inspection of plumbing, and supervision and construction of the storm drainage system.

Refuse Collection and Disposal

Towards the end of the depression of the 1930's, promiscuous dumping along the highways of Prince George's County, largely by Washingtonians, and the operation of dumps by county residents, again largely for the convenience of Washington refuse haulers, created a public demand that these nuisances be halted. It was obviously a job for some public agency and the Sanitary Commission, which had been given the authority to control refuse disposal some 20 years before but which had never exercised it because of lack of public necessity or demand, was selected to be the "whipping boy."

After a study of the problem it was decided to build a mixed refuse incinerator with a capacity of 70 tons per day at centrally located Bladensburg, and to permit, under license only, dumps of non-combustible materials. These steps were taken in 1939. The incinerator now disposes of about 20,000 tons of refuse a year, and objectionable dumps in the county have been practically eliminated. Some communities still persist in disposing of garbage on hog farms beyond the district limits, however, and the police have to conduct periodic drives to stop promiscuous dumping along roadsides by individuals.

The incinerator is a hand-feed type, entirely unsuited to the amount of refuse which it is obliged to handle. The furnaces, however, have performed very satisfactorily without using auxiliary fuel, and forced draft is used only to a limited extent. The preheaters proved to be more of a nuisance and expense than an aid, and were removed.

One of the features of the operation of the Bladensburg incinerator has been the salvage of materials. Tin cans and cardboard are baled; crates, baskets and boxes are salvaged; and glass is reclaimed. These operations supplied valuable materials for the war effort and, due to prevailing high prices, were an important source of revenue. Some

of the items are no longer salvaged, as it is intended to make the salvaging operations pay for themselves.

Due to the great wartime increase in wages (about 100 per cent), the early operating surpluses at Bladensburg changed to operating deficits during 1942 to 1945 inclusive, and the deficiency was made up out of water receipts as provided by law. Salvage operations caused a slight operating surplus again in 1946 and the disposal rate has been raised from $1.50 to $2.00 a ton to provide for a probable decrease in salvage receipts and repay the water account for sums advanced.

During the war there was a grave danger that the refuse service, which was provided by private collectors in Montgomery County, would collapse because of the manpower shortage and difficulties in replacing equipment. As a result, the county commissioners requested the sanitary commission to undertake the collection and disposal of refuse in this suburban area. Aware of the public necessity, the commission acceded to the request and entered into a study of the problem in 1942. An earlier study made by the commission's engineers some 18 years before fortunately gave a good idea of the basic proposition; and the amount of refuse to be disposed of, the number of routes and men required, and the amount and kind of equipment needed were quickly determined. Disposal presented a serious situation. Materials, equipment and labor to build an incinerator were unobtainable, and suburban Montgomery County, one of the fine suburban residential areas of the country, would not tolerate dumps within any practical hauling distance. After careful investigation, it was decided to dispose of the refuse in land fills, if sites could be found.

Because of the type of development in the area to be served and the topography and elevation of the land, sites were very scarce, but one was finally selected which, although not ideal, would apparently do. Land-fill operations began in November 1943, and continued on this and two other sites until July 1946, when the Lyttonsville incinerator was put in operation.

As the land-fill sites were not chosen for the purpose from physical and public relations standpoints, a site was soon purchased for an incinerator, storeyard and ash dump along the freight railroad at Lyttonsville, which is fairly centrally located in the refuse-collection area. A study of incinerator design and operation was then begun, and a pit and monorail design with hopper feed was finally adopted. Two 75-ton nominal daily capacity Monohearth furnaces, using forced draft when necessary, were installed, with the expansion chamber, main flue, chimney and building designed large enough for a third unit of the same capacity. Preheaters were eliminated, and air ducts were installed instead, to permit a considerable range in the selection of air temperatures for combustion and also moderate the furnace room temperatures when desired. The furnaces are equipped with ash hoppers which dump the ashes into a waiting truck below. All refuse material is weighed on an automatic recording scale before dumping. On test the incinerator exceeded the capacity requirements by about 33 per cent and has operated very satisfactorily since.

An attempt, which is believed successful, was made to design a utilitarian yet attractive structure which would not detract from the appearance of the locality. It is well that this precaution was taken, for a fine-looking stone tele-

vision station has since been built right across the road from the incinerator.

In instituting the refuse collection service, many problems were encountered. The worst was labor: collecting garbage is never a desirable job, and competition from other employers was especially severe during the war. Another problem was caused by the precedent of the private collectors, who had been collecting the refuse at or near the back of the suburban residences. The people disliked having refuse cans on the street in front of their homes, and there were few alleys. It was therefore necessary to continue the costly and troublesome practice of picking up the refuse behind the houses.

Equipment was hard to obtain. After making the commission buy all the used trucks it could get, the War Production Board let it have some Chevrolet cab-over-engine trucks with Philadelphia trash bodies. Although the commission is converting to the packer type unit as its trucks wear out, it is true that the War Production Board trucks did a good job. Galvanized tubs for carting refuse were also scarce, and burlap sacks were used to carry the refuse from the houses. A service garage also had to be rented and set up, as the main garage was too far from the refuse-collection area.

Each truck has a total crew of 5 men and collects from about 450 houses a day. Two refuse and one ash collection, when needed, are made weekly at each house. Refuse, which is not separated, amounts to about 2.5 lb. per capita per day. The Lyttonsville incinerator is now handling about 20,000 tons of refuse annually. This amount is produced by over 50,000 people on the commission's collection system, by private haulers serving stores, apartments and some municipalities, not served by the commission, and other haulers, principally chain groceries.

Refuse service per residence costs $1.25 per month. The service pays its own way. The cost would be materially decreased if the householders would place their refuse in cans at the curb.

Plumbing

Another of the duties of the commission is the supervision and control of all plumbing within the sanitary district. General authority for the issuance of permits and inspection of plumbing was delegated in the act creating the commission, but it was not until 1925, when the danger and cost to the public of uncontrolled plumbing practices were realized, that the commission issued plumbing regulations, which included the licensing of plumbers within the sanitary district.

This year an estimated 3,500 water service connections of all sizes and a like number of sewer services will be installed by the commission. A chief plumbing inspector, five inspectors and a clerical staff handle the inspection of all plumbing to and in the buildings served by the connections, which will include a large number of apartment structures, commercial buildings and residences, along with some light industrial projects. In addition, they will inspect all additions to, and modifications in, existing buildings. The inspectors are doing a job of great value to the people of the district.

All persons doing plumbing work in the sanitary district must be licensed by the commission. Examinations in plumbing for master or journeyman plumbers are held at stated times by the commission. The percentage pass-

ing is not very high and, of course, there are some complaints about the strictness of the examinations. The value of good plumbing has been so well demonstrated over the years to the plumbers themselves, however, that they want the standards upheld or improved. All master plumbers are bonded to the commission.

The inspection of plumbing is now functioning in a manner which makes it somewhat difficult to remember the troubles that were encountered originally with pipes that were covered up before inspection, failures to call for final inspection and other headaches. There is also little plumbing work now being done without permits or by unlicensed men. Gas fitting work is also supervised by the commission.

Venting and cross-connections are the principal plumbing problems. Just before the war the commission ran some full-scale experiments, which proved to be very valuable, to ascertain proper venting requirements. In the past two years an intensive drive has been carried on to eliminate cross-connections. Laundries, dairies, swimming pools and air-conditioning systems have been found to be the worst offenders. It is believed that the cross-connection field has been reasonably well covered, but it is necessary to check back on violators from time to time to be sure that the correction is permanent.

Storm Drainage

The remaining major function of the commission is the supervision of all storm drainage in the sanitary district and the construction of major storm drainage projects to the extent to which the General Assembly authorizes the issuance of bonds. The cost of the bonds is paid for out of an *ad valorem* tax over the whole area.

General authority over storm drainage was vested in the commission in 1918, but it was not until 1943 that the problem was approached objectively. The area was building up so rapidly that the inadequacy of existing or non-existent storm drainage systems became intolerable. The commission therefore asked the legislature for authority to issue $300,000 in bonds for storm drainage, and to assess the cost against the property benefitted.

After four years this plan of financing still seems to be logical. In the first two years after the law was passed, however, hearings on proposed projects revealed that, although practically everybody wanted the drainage projects built, only a small minority were willing to be assessed their cost. As a result, the 1945 session of the General Assembly was asked to grant authority to issue $1,000,000 in bonds to be paid for by a general tax and to repeal the benefit assessment feature of the original act. This is the basic law under which the plan is now operating, except that the 1947 legislature authorized the issuance of another million in bonds.

Present procedure is to hold public hearings on projects which, after an engineering study, it appears desirable to build, and the commission decides, on the basis of the facts developed at the hearing, whether or not to go ahead with the project. The funds are divided equally between the two counties.

Under the law a developer, municipality, taxing district or county can construct storm drainage, provided the plans are approved by the commission. As a matter of fact these agencies should handle local storm drain-

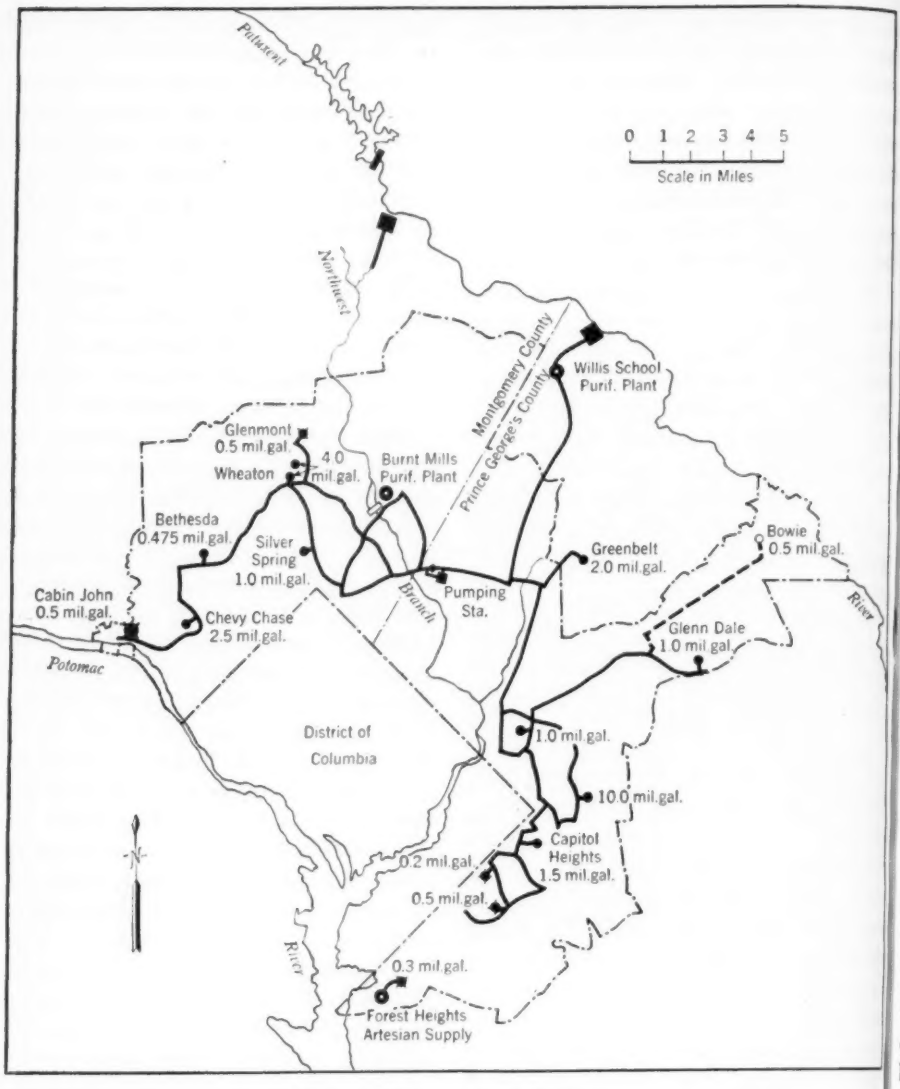


FIG. 9. Plan of Water Storage

age problems, leaving the correlation of all construction and major projects to the commission. It appears to the authors that there is a tendency on the part of some of the agencies to evade their storm drainage responsibilities. For the protection of their street and road maintenance budgets alone, these agencies should require developers operating within their jurisdictional areas to install storm drainage when they build the streets in their development. Perhaps the commission should have this authority, but it has consistently tried to keep out of the road business which it considers foreign to its pur-

pose. Of course, the solution lies in the creation of an overlying authority exercising all municipal functions in the Maryland-Washington metropolitan area. Two counties and several dozen small and medium-sized municipalities are located within the area, however, and hold firmly to the principle of local self-government.

The commission uses the rational method in designing storm drainage structures, establishing by detailed study the runoff coefficients of the area involved and designing generally for a 10-year storm, unless special conditions warrant use of another period.

The 1947 General Assembly designated the commission as the public agency to deal with the federal government in the matter of flood control and navigation of the Anacostia River, which traverses the district. This project is now being processed by the War Department, but the commission finds it very important and valuable to correlate its storm drainage studies with the United States Engineer's report.

Technical Accomplishments

The story of the sanitary district would not be complete without a discussion of some of the principal technical problems encountered and the methods used by the commission's engineers in their work.

Filtered Water Storage

One of the major problems which has persisted is due to the topography, which offers few suitable sites for large volumes of filtered water storage. This is unfortunate, for the area is predominantly one of homes, lawns and gardens, and has very high peak water demands. The relatively low filtered water storage-filter capacity ratio requires the commission to maintain a large filter capacity.

As sites for large reservoirs are not available, numerous standpipes and elevated tanks have been erected on suitable locations in the various pressure areas, as shown in Fig. 9. Recently a 10-mil.gal. low-head standpipe was built on a site made suitable by moving some 48,500 cu.yd. of sand and gravel. Enough land was bought for four such structures, but further grading will be required. Welded steel construction was used both because it was economical and because it will avoid the leakage troubles which are likely with other construction, and which might be very serious on the particular foundation used.

There are several low-head range tanks as well as some other types. It is probably unnecessary to advise the avoidance of such tanks if they are not needed. They look attractive but cost more money. Stairways and tubular columns are being incorporated in the tank designs, because ladders are too hard to climb and tubular columns look better and are easily maintained. Cathodic protection is used to some extent on both tanks and standpipes.

Filters

Morse and Willis School Filter Plants

The commission's two filter plants are of all-welded steel construction. They consist of a series of concentric steel shells, each annular ring containing one or more of the component units

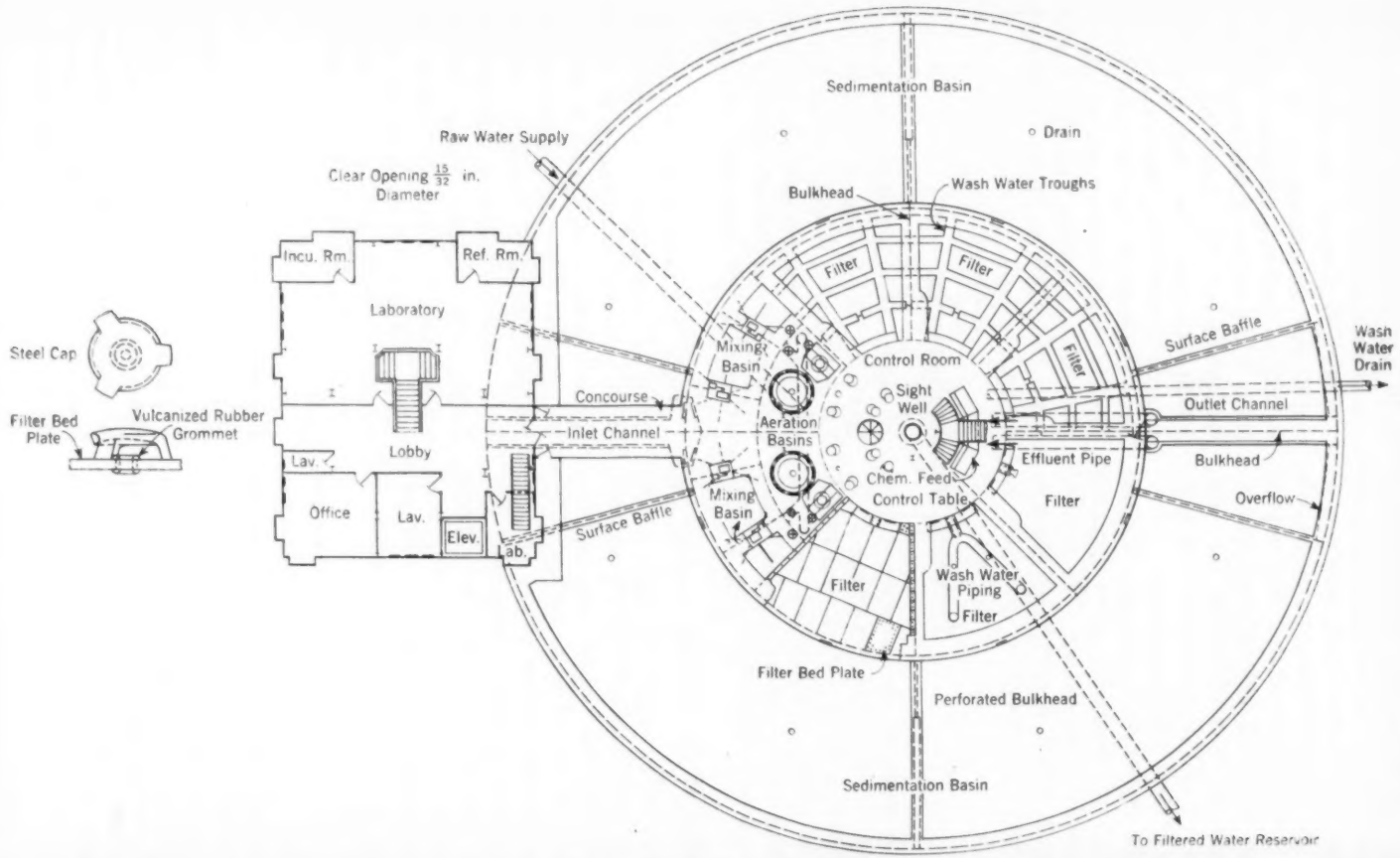


FIG. 10. Willis School Water Filtration Plant

of a conventional rapid sand filter plant. The design was conceived by the late Robert B. Morse, the first chief engineer of the commission.

The plant at Burnt Mills, named for Mr. Morse, has two 5-mgd. units, and the Willis School plant (Fig. 10, 11) is a single 10-mgd. unit. It is planned to build a duplicate unit at Willis School next year; eventually four will be built.

The all-steel plants are more economical to construct than the conventional concrete plant; they are compact and simplify operation; they do not leak; and they have not proved difficult or expensive to maintain. Originally, expensive protective coatings for the steel were thought necessary, but an inexpensive paint has been found which is quite satisfactory. The filters can be built on a sand cushion foundation, which is also being used for low-head standpipes.

The Burnt Mills head houses, as they are called, are of steel frame, brick and reinforced concrete construction. At Willis School they are entirely of steel.

Fig. 10. Willis School Water Filtration Plant

Filter Plant Waste Disposal

When the Morse plant was built at Burnt Mills, the filter plant wastes were merely discharged into the Northwest Branch of the Anacostia River, which flows alongside the plant. A different situation exists, however, at the Willis School plant, which is located on a high ridge and hence is well removed from any sizeable stream.

It was apparent, because of the smallness of the watercourse into which the filter wastes would be discharged, that some method would have to be devised of regulating the flow of filter wash water, sedimentation basin discharges, pumping overflows and suspended matter. Lagooning, discharging into other watercourses and dredging were investigated and found too expensive or impracticable. After making sedimentation tests of filter wash water and computations of the volumes of sediment which might be produced by the plant, it was finally decided to construct a settling basin for the filter plant wastes with a 1-hour detention period above 4 months' sediment storage and a take-off weir over which the flow could be regulated. Subsurface investigations of the most economically located site disclosed that the basin could be built by cutting into a slope and constructing a suitable embankment downhill with the excavated material. The basin was lined with concrete and no leaks have been observed. A suit was brought by the town of Laurel to prevent this method of filter plant waste disposal, but the circuit court ruled in favor of the commission.

Dams and Reservoirs

The commission constructed an Ambursen dam, 20 ft. high, on Northwest Branch at Burnt Mills to furnish a gravity supply of water to its filtration plant. The intake reservoir had a volume of 30 mil.gal. at spillway level and 50 mil.gal. with 4-ft. flashboards, which were once washed out in a flood of 211 cfs. per square mile. The watershed area is 26.9 square miles. The Ambursen dam was chosen because of foundation rock conditions. Eventually the development of the area will cause the abandonment of the installation, but at the time the resources of the sanitary district did not justify the expense of going to the Patuxent River for its water supply. The dam and reservoir will be included in the local park system.

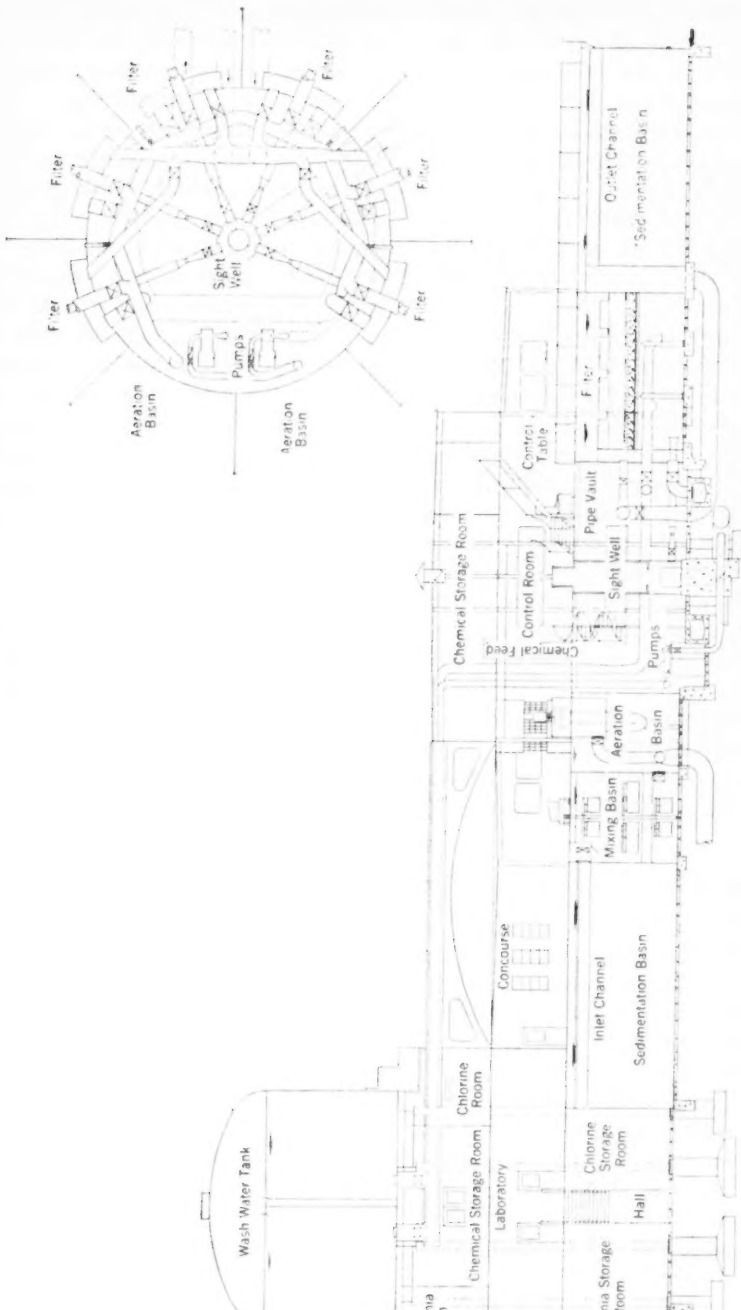


FIG. 11. Section and Pipe Vault Plan of Willis School Water Filtration Plant

The dam on the Patuxent River, near Brighton, is also of the Ambursen type. Numerous reservoir sites were investigated before selecting the one adopted. Although the site selected was not the most economical for the dam itself, it was found that, when reservoir volume and the road relocations required were taken into consideration, the choice of site had nevertheless decreased the total cost of the project by approximately $400,000. The dam is 1,000 ft. long and is 62 ft. high at normal pond level. It is equipped with thirteen Taintor gates, each 15 ft. high and 18 ft. long, which are operated by gasoline and electric hoists. The spillway is designed for a flood of 791 cfs. per square mile. The volume of the resulting impounding reservoir, after making allowance for silting, is 6,118 mil.gal. and it has a water surface of 775 acres. A 26-ft. roadway with a 4-ft. sidewalk is carried over the top of the dam to take the place of a road flooded by the reservoir. The Ambursen design was chosen because of foundation conditions. A 200-hp. hydroelectric station consisting of dual turbines and appurtenances, which supplies power for heating and operating the Taintor gates, is built in the dam, as required by the construction permit.

The commission owns 1,700 acres around the reservoir to which it is applying soil conservation, reforestation and other land-use practices. Grazing and hay making are carried on where forestation is not practiced. The commission is embarking on a soil conservation program on the whole watershed in conjunction with the local soil conservation officials, farmers and, it is hoped, county and state agencies. Six 24-in. undersluices have been installed in the dam to pass density currents but it is believed that the application of soil conservation methods to the whole watershed will be much more effective in reducing silting.

The commission proposes to construct another dam further downstream on the Patuxent River. It will probably be of the gravity or arch type, as rock conditions at the site appear most favorable. A hydroelectric station will be installed which will furnish much of the power required to raise the water to the Willis School filter plant.

Design of Piping

Water Distribution System

Cast-iron pipe is used practically throughout the water distribution system, although steel and prestressed concrete have been used in supply lines. Pressures in the distribution system mains vary from 40 to 125 psi. static, with an average of about 75 psi. Copper services are used, although in the early days many of galvanized wrought iron and cast iron (and Tube-loy during the war) were installed.

The loop plan has generally been followed in designing the distribution system. This plan was justified, as hitherto the scattered nature of the development of the area permitted good gridironing only at places where the area was closely built up. Now, as the open spaces between developed areas rapidly disappear, future main feeders will generally be planned on the tree-design principle. A more complete grid will permit this plan, with its resultant economies.

The hydraulic gradients between elevated storage points are being increased where possible in order to increase the main feeder capacities.

Fire hydrant spacing in residential areas has been about 400 ft. The

TABLE 2

Cradle Schedule for Sewer and Culvert Pipe

Pipe Diam. *in.*	Kind of Pipe	Depth to Invert			Pipe Diam. *in.*	Kind of Pipe	Depth to Invert		
		No Cradle	Low Cradle	High Cradle			No Cradle	Low Cradle	High Cradle
6	VCPD	6.5	24.0	V.G.	21	RCSP	11.0	22.0	41.0
	VCPX	V.G.	V.G.	V.G.		RCCP	14.5	37.5	V.G.
	CSPX	V.G.	V.G.	V.G.					
					24	VCPD	8.0	12.5	16.5
8	VCPD	6.5	14.0	V.G.		VCPX	14.0	30.5	V.G.
	VCPX	29.5	V.G.	V.G.		CSPX	14.0	30.5	V.G.
	CSPX	29.5	V.G.	V.G.		RCSP	9.5	16.0	22.5
						RCCP	11.5	21.5	34.0
10	VCPD	6.5	13.0	24.0		RCCPX	16.5	41.5	V.G.
	VCPX	16.5	V.G.	V.G.					
	CSPX	16.5	V.G.	V.G.	27	RCSP	9.5	15.5	21.5
						RCCP	12.0	21.0	31.5
12	VCPD	6.5	12.5	19.0		RCCPX	17.5	43.0	V.G.
	VCPX	16.0	V.G.	V.G.					
	CSPX	16.0	V.G.	V.G.	30	RCSP	10.0	16.0	21.0
	RCSP	15.0	V.G.	V.G.		RCCP	12.0	20.5	29.0
	RCCP	24.5	V.G.	V.G.		RCCPX	18.5	44.0	V.G.
15	VCPD	7.0	12.5	19.0	33	RCSP	9.0	14.0	17.5
	VCPX	17.5	V.G.	V.G.		RCCP	11.5	18.5	24.5
	CSPX	17.5	V.G.	V.G.		RCCPX	16.5	32.0	56.0
	RCSP	13.5	V.G.	V.G.					
	RCCP	24.0	V.G.	V.G.	36	RCSP	9.5	14.0	18.0
						RCCP	12.0	19.0	25.0
18	VCPD	7.0	11.5	15.5		RCCPX	17.5	33.0	57.0
	VCPX	14.5	V.G.	V.G.					
	CSPX	14.5	V.G.	V.G.	42	RCSP	10.0	14.0	17.5
	RCSP	11.0	23.5	V.G.		RCCP	13.0	20.5	27.0
	RCCP	16.5	V.G.	V.G.		RCCPX	19.0	35.0	57.0
21	VCPD	7.5	12.5	17.0	48	RCSP	9.5	13.5	16.0
	VCPX	15.0	V.G.	V.G.		RCCP	13.0	20.0	25.0
	CSPX	15.0	V.G.	V.G.		RCCPX	18.5	31.5	45.0

Abbreviations

VCPD —Vitrified clay pipe, double strength
VCPX —Vitrified clay pipe, extra strength
CSPX —Concrete sewer pipe, extra strength
RCSP —Reinforced concrete sewer pipe
RCCP —Reinforced concrete culvert pipe, standard strength
RCCPX—Reinforced concrete culvert pipe, extra strength
V.G. —Very great. This is in excess of $15 \times B$.

Criteria

(Pipe specifications A.S.T.M., external load, Marston formula)

$W = wcB^2$ (w = 110 lb. per cu. ft.)

6–15 in. id. B. = od. + 2 × 8 in.
18–21 in. id. B. = od. + 2 × 10 in.
24–30 in. id. B. = od. + 2 × 12 in.
33–42 in. id. B. = od. + 2 × 15 in.
Over 48 in. id. B. = od. + 2 × 18 in.

Factor of Safety

VCPD—1.50	RCSP —1.25
VCPX—1.50	RCCP —1.25
CSPX—1.50	RCCPX—1.25

Sanitary sewer construction; no superload. Coefficient C based on wet clay. Low cradle = 160, high cradle = 200 per cent. RCP based upon 0.01 in. crack. Plain pipe based upon ultimate strength. This tabulation is based on trenches with skeleton sheeting. It does not apply to trenches sheeted solid.

authors would like to increase this distance because the pressures are good and also because it is not thought that the theoretical ratings of the National Board of Fire Underwriters based on such spacing are sufficiently reflected in insurance rates to provide economic justification for the spacing (serving about 140,000 sq.ft.) of 400 ft. In commercial, apartment and residential areas, the spacing is approximately 200 ft.

Valving of mains is being increased, as the commission can now better afford the cost of additional valves to decrease the extent of shut-down areas. The general intention is to achieve 4-valve shutdowns, although this is not an inflexible rule.

In the water system grid, 6- and 8-in. mains generally alternate, although a 6- instead of an 8-in. main is ordinarily used if the spacing does not work out evenly. Unsupported 6-in. mains are limited to 1,200 ft. and unsupported 8-in. mains to 2,000 ft. Ten- and 12-in. mains generally alternate at approximately 3,500-ft. spacing, with 16-in. mains at about 6,000 ft. Mains 24 in. in diameter are about 10,000 ft. apart. In apartment and commercial areas, the minimum main size is 8-in.

Sewer System Design

Sewer design has had to be revised from time to time to meet the changing development in the area. Designing for 10 to 15 persons per acre was common in the early days, with no allowance made for areaway drains. There was practically no apartment or industrial development. Later designs provided for 25 persons per acre, with an allowance of five 30-sq.ft. areaways per acre and 3 in. per hour of rainfall, plus an additional flow of one-third to provide for unforeseen development. There were a few apartment developments, with promise of more, and nearly all residences had cellars and areaways. Nowadays, with smaller families (although not as small as just before the war) and fewer houses being built with cellars, designs provide for 18 persons per acre and three areaways in residential areas. The commission is generally able to design lateral sewers for particular apartment and industrial developments these days, although the cumulative effect of such projects may require the construction of relief sewers earlier than anticipated originally. An assumption of 100 gpd. of domestic sewage flow per capita has been used throughout the period of the commission's operations.

Few trunk sewers are designed for the probable ultimate flow; instead they are built with a capacity sufficiently large so that the construction of the relief sewer at a later date will be more economical than building the ultimate size sewer originally. The commission thus obtains a second guess on its capacity needs, and in addition reduces its borrowings until the assessable value of the area is greater.

Sewer Pipe Design

Most of the sewers in the commission's system are vitrified clay pipe, although during the war plain and reinforced concrete pipe were substituted. Originally double-strength pipe was used, with cradles where required, but extra-strength pipe has been adopted as being more economical. Table 2 shows the designs used.

A unique design is used where timber foundation is required in the trench. Upon investigation conventional designs were found inadequate,

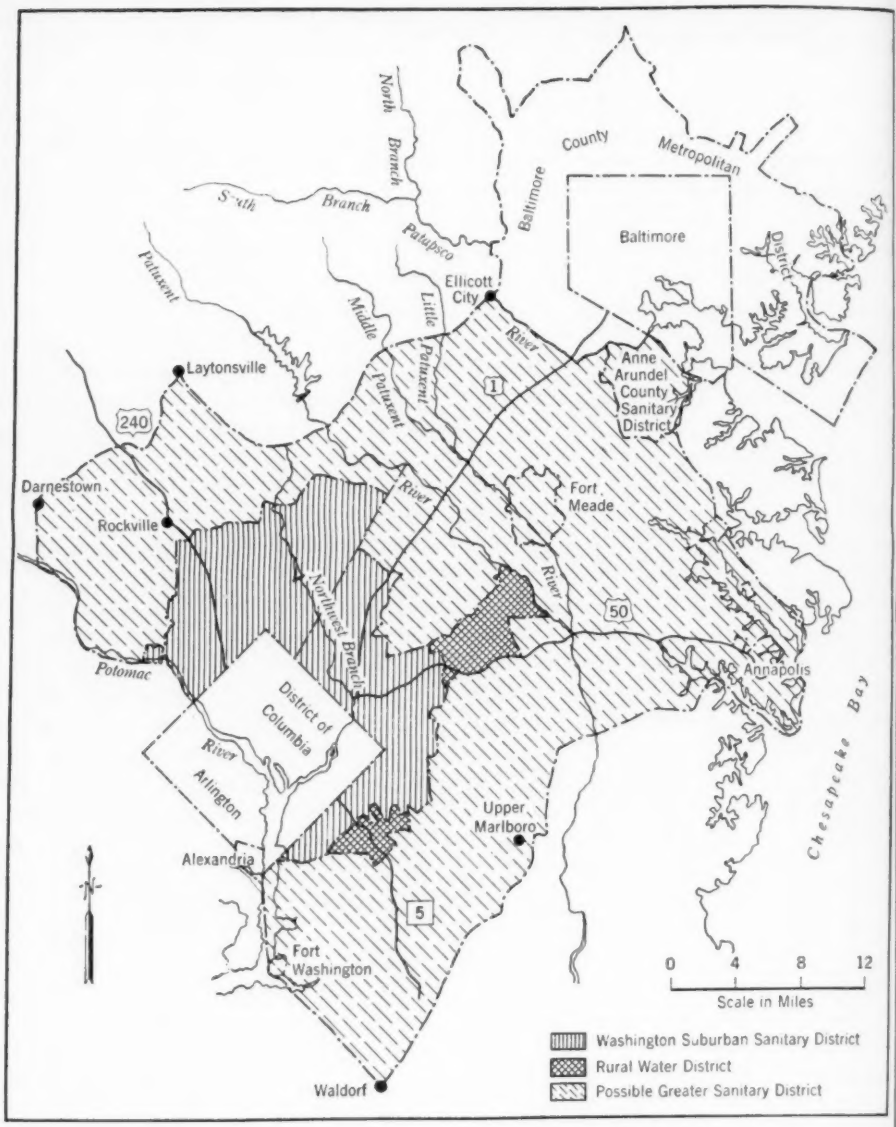


FIG. 12. Possible Greater Sanitary District

and now the commission engineers actually design the pile bents and use timber stringers with concrete, using large nails closely spaced to bond the two and take the shearing stresses.

Only a few sewer failures have been discovered, and these were in double-strength pipe.

Storm Drain Design

In designing storm sewers the rational method is used. Storms of 10-year frequency are assumed, except where damage to property or requirements of public safety indicate that a storm of lesser frequency should be

used. Runoff coefficients are based either on the actual measured impervious and pervious areas of the tributary watershed or on measurements of typical areas on the watershed. Fortunately the commission has extensive maps of the area, and much of the necessary detail as well as information on slopes is available without extensive surveys.

It has been found that, in order to avoid trouble, storm drainage construction should be started at the lower end of a watershed and then carried upstream. When a part of a drainage system is built starting at any other point, there are invariably difficulties with the people below, no matter how little they are damaged—if at all—or how pressing the need for the construction above. Riparian rights seem to be quite well established in law.

Economy dictates that as much open channel construction be used as possible, so the commission follows the axiomatic drainage principle: "Get rid of the water as soon as possible," disposing of it into watercourses or open channels as directly as practicable. The use of dual streets with an open channel or watercourse between the roadways is encouraged, although it increases the cost of service connections, because there is an appreciable net saving to the public.

It may be considered contrary to the democratic process, but the authors seriously question the advisability of public hearings on proposed storm drainage projects which are paid for out of a general tax. Self-interest enters so largely into the discussions, and the views expressed are therefore so diverse, that little benefit and much confusion result. Hence worthwhile projects which would provide needed relief are frequently delayed or even abandoned.

Water Services

A ¾-in. service connection with a ⅝-in. meter is used for single residences and a 1-in. connection is used where a double meter setting serves two adjacent residences. Meter settings consist of a 2-ft. length of 18-in. vitrified pipe, in the bell of which is placed a tapered concrete housing. A cast-iron meter frame and lid cover the housing. The housing is generally placed at the street line, where the commission's installation ends and the owner's connection begins.

Curb cocks are used where meters are set inside buildings, but such placement is not usual practice. Serious consideration has been given lately to the adoption of inside settings, due to the expense and trouble to which the commission has been put in restoring outside meter settings disturbed by public and private grading and development operations. Bills for the cost of such restoration are difficult to collect, although the commission sees no good reason why they should be.

Future of Sanitary District

Figure 12 shows the areas of the present sanitary district in which both water and sewerage service are provided; the rural areas in which water service only is provided—at higher cost than in the suburban sections; and the possible extent of a greater sanitary district which could well be served with water by the expansion of the commission's development of the Patuxent River. In certain localities, notably along the Potomac River below Washington, it may be found more economical to use a supply of ground

water, but such areas are so related to the major area that they should be included in it for economic reasons. A sanitary district rather than a water district is suggested because the problem of supplying water to the area outlined would be affected in so many ways by the disposal of sewage in the area that both should preferably be controlled by the same agency. The commission has found the joint administration of water supply and sewerage both practicable and desirable.

The rural water districts mentioned are predominantly rural areas adjacent to the suburban area with sufficient population economically to justify the extension to them of a piped public water supply. They are not sufficiently populated at this time, however, to justify the construction of sewerage systems.

Obviously the cost of supplying water to these rural sections is greater than to the more densely peopled suburban and urban sections, and it would be unfair to saddle on the latter this additional cost. The rural areas are therefore charged the cost—which averages approximately $70 per year per house—of extending water service to them. This figure is really very attractive, considering the savings effected by eliminating the construction, maintenance and operation of an individual well supply and by the reduction in fire insurance rates. A potable and adequate supply of water, convenient and safe, is thus supplied at a cost that compares well with other utility services.

As soon as it is economically justifiable, other areas will undoubtedly be added, and when and as the rural areas develop sufficiently, they will demand and obtain sewerage also.

Although practical considerations require that reasoning be kept on an economic basis, there are sociological and practical planning reasons which can well be advanced to justify extending sanitary services into rural areas. The authors believe that this principle of extension will be applied in the future to a much larger area around Washington than at present, and that it can be followed advantageously in many other localities.

Acknowledgment

No discussion of the work of the Washington Suburban Sanitary District would be complete without some reference to the late Robert B. Morse, its first Chief Engineer, under whom the authors served for many years. More than any other person, he was responsible for the successful launching and directing of this project, which has attained such magnitude.

He was connected with the work from its very inception, supervised all the preliminary studies and reports in the six years prior to its commencement, and collaborated to a very important degree in the working out of the financial plan and the drafting of the organic act. He was responsible for the planning of the engineering features of the entire project, and his great engineering ability, combined with rare judgment and foresight, made possible its successful execution.

Water Meters Earn Their Keep

By George C. Sopp

A paper presented on May 15, 1947, at the Pacific Northwest Section Meeting, Victoria, B.C., by George C. Sopp, Supt. of Meters and Services, Dept. of Water and Power, Los Angeles, Calif.

WATER meters are just as definitely essential equipment for the modern water works utility as accurate weighing scales are for the butcher, or the meter and recording device of the gasoline pump are for the automobile service station. If a man buys 1 lb. of meat for a family of three while his neighbor buys the same kind of meat, but requires 2 lb. because he has a family of six, it is natural that we accept the simple fact that the man who purchases 2 lb. will pay more than the man who receives only half as much. Yet there are still many water departments today which charge a flat rate for water, causing the family of two to be charged the same rate for the water it consumes as the family of six, although it is obvious that there is a great difference in the amount of water used by the two customers.

The American motorist would not long tolerate unmeasured and inaccurate dispensing of gasoline into the gas tank of his automobile, for he would not have the confidence and assurance that he was obtaining a known quantity of the commodity at a fixed unit price. He knows that, if he uses his automobile twice as much in summer as he does in the winter, his fuel costs will increase, and he is willing to pay the additional cost for the extra use.

The charge for the use of water should likewise be on an accurately measured unit basis, equitably distributed over all customers, for each customer should stand his rightful proportionate share of the water utility operational, replacement and normal expansion costs.

Many people still maintain that water, as "the gift of God," should be free. This claim is essentially correct; however, we find that this "free gift" is not always conveniently located nor available in sufficient quantities when and where required; therefore water consumers, as recipients of this gift, should be willing to pay their share of the transportation cost, bearing in mind particularly that it is delivered directly to their homes and, in addition, is ready for immediate use both day and night. It takes money to secure a water supply: to gather, store, filter, sterilize, condition, pump and distribute water; to expand systems, maintain adequate service, provide for emergencies and future improvements, not to mention the costs of administration and accounting.

If a water works system is to be operated on a sound basis, guesswork about charges must stop. Ample water must be provided for all legitimate uses, and water rates must be low, but they must be equitably applied, and

proper distribution of operation and maintenance costs must be made. Universal water metering of a water works system is the only means by which these aims can be accomplished.

The community in some manner must pay for its water service. Sufficient revenue must come from the sale of water to make the system self-sustaining. No deficit should arise to be passed on to harass overburdened taxpayers, for a modern water utility should be self-supporting.

Postwar economic conditions, together with increased efficiency in industry and general business, are making heavy demands for utmost efficiency in public service. Public utilities engaged in selling gas or electric energy follow the practice of metering all consumers' services, as they could not long exist with a percentage of waste and leakage as high as is tolerated in flat rate water systems.

The flat rate or assessment method of charging for water has come down from the early days of the water works history. It carries the acceptance of custom and the hearty approval of wasteful users. They contend that an unlimited domestic supply is necessary to preserve our high standards of sanitation; that any other plan threatens to impair our habits of cleanliness. In some places, of course, the retention of the flat rate is dictated by political expediency.

Metering Los Angeles

Without means to check accurately all consumption, water waste and leakage continue to increase. In some unmetered or partially metered cities this loss has reached enormous proportions, as evidenced by the high daily per capita consumption. In December 1901, when the city of Los Angeles acquired its water system, there were 141.02 miles of water distribution mains 4 in. and larger and 23,180 service connections, with only 319 water meters in service. Los Angeles at that time had an area of only 43.26 square miles, and a total population of 102,479. At that time the per capita consumption was over 300 gpd.

On June 30, 1946, there were 337,118 domestic, industrial and irrigation water meters in service in Los Angeles and 4,366 miles of water distribution mains 4 in. and larger, exclusive of the Owens River Aqueduct. The per capita consumption for 1945–46 was only 152 gpd. The area of the city of Los Angeles on June 1946 was 458.88 square miles, and the population was 1,827,000. This comparison of areas, population, per capita consumption and meter data indicates that 100 per cent metering of the water system does eliminate the use of water above essential requirements without impeding the growth of the community, either as a residential area or as an industrial center.

It may be well to point out that if consumption for 1945–46 had been experienced at the same per capita rate as that of 1902, the total domestic consumption would have been 510 mgd. instead of the 1945–46 average of 254 mgd. If the people of Los Angeles had continued to consume water at the rate of 300 gpd. per person, as in 1902, the amount of water supplied in 1946 would have sufficed for a city with a population only half as large as the present city of Los Angeles. Continuation of such a high per capita consumption would definitely have limited the growth of Los Angeles as a residential area, and most assuredly as an industrial center.

Purchase of Meters

Acquiring water meters and applying them effectively in a water works system should demand the same careful study and evaluation of their design, operation, standardization of working parts, workmanship, efficiency, durability and maintenance costs as would be applied in the selection of a pump or any other specialized machinery or equipment for use in a water works system.

The purchasing of water meters by a water utility can be a highly important factor in the successful operation of the system, for it may mean the difference between the economic success or failure of the utility, particularly if the cost of producing water is high.

Good metering equipment has a long life in a water system and permits the utility to obtain full revenue from customers for their use of water at minimum meter maintenance costs. Water meters which are purchased by a water utility merely because of their low cost may never give satisfactory service and will unquestionably result in increased maintenance costs. In addition their inefficiency will cause the customers to lose confidence in the general efficiency of the utility. Meters which are purchased for their high standard of performance, however, as well as their adaptability to the character of the water service to be rendered, will in the end cost much less to maintain and will outlast poorer water meters, giving top performance and proving completely acceptable by the customers.

Certain controls should be established by the utility to guarantee the purchase of the best meter available for the type of service for which the meter is to be used. The Los Angeles Dept. of Water and Power established standard specifications for water meters in order to assure the purchase of meters best suited to its system and also to guarantee high efficiency and long life in service at low maintenance cost. It has been found that, by specifying certain general design standards and operating characteristics for water meters, improvements in design, operation and efficiency have been effected and frequently have been adopted by the meter manufacturers as standard for that particular make, style or size of metering equipment.

In general, some of the most important factors to be considered in the selection of the right type of water meters are:

1. Long-range accuracy
2. Durability
3. Precision machining of meter parts for interchangeability
4. Repairability
5. Non-corrosiveness of metals and materials.

The initial cost is not considered one of the most important factors. It is regrettable that, in the purchase of water meters by many water utilities, the initial cost (even down to a few pennies) determines the choice. Usually this attitude exists because the purchase of meters is made by those who are not properly informed on the subject.

It is the firm belief of the author that the responsibility for the selection of water meters by most water utility systems should be left solely in the hands of the water works operator, who is responsible for their maintenance and efficiency and is therefore in the best position to judge their relative merits. If this procedure were followed, better and more efficient meter-

ing of our water systems would result. The selection of meters by those unfamiliar with the characteristics, efficiency and repair processes of water meters should be condemned by those water works utilities interested in the over-all efficiency of their systems.

Low-Flow Accuracy

There has been much discussion and wide differences of opinion among water works men concerning the relative value of accuracy in water meters. Many old-time meter men claim that close accuracy at low flows is not generally essential because the large percentage of water used by the consumer is at rates of flow above 4 gpm., and that such higher standards of accuracy at low flows would be difficult for the manufacturer to maintain consistently, especially on a high production basis. Such accuracy, it is therefore argued, would result—if it were obtainable—in a much higher cost per meter.

Some water works men have made exhaustive studies of the rate-of-flow characteristics of consumer demand, and invariably these studies have concluded that low-flow use of water by consumers does account for a fairly large percentage of the total consumption. High accuracy, therefore, is seen to be an extremely important part of over-all meter efficiency. It has been ascertained that from 12 to 15 per cent of all water used is at rates of flow of 0.25 gpm. or less.

TABLE 1

Specification Test for Displacement Meters

Size	High Point		
	Low Flow*	Flow	High Flow
in.	*gpm.*	*gpm.*	*gpm.*
$\frac{5}{8}\times\frac{3}{4}$	0.25	2	16
$\frac{3}{4}\times 1$	0.50	3	21
1	0.75	5	43
$1\frac{1}{2}$	1.00	7	85
2	1.25	10	125

* Registration accuracy requirement of 97 per cent for all low-flow rates.

It would seem that the water works industry is attempting to achieve that to which it is rightfully entitled—100 per cent registration of both high and low flows. It is just sound business practice to expect the ultimate in efficiency for all equipment. This especially includes water meters as they are the "recorders" of consumers' use of water upon which revenues are based. Water meters should have a high degree of accuracy at all flows if there is a shortage of water, or if water production costs are high.

The first and most logical question concerning this higher accuracy standard is whether water meters can be produced embodying this higher degree of accuracy for water works utilities without being prohibitive in cost. The history of the Los Angeles Dept. of Water and Power shows conclusively that it has been possible to raise the standard of requirements for water meters gradually, until now the goal of 100 per cent efficiency is within sight. The regular shop specification test for all new positive displacement type water meters in sizes from $\frac{5}{8}\times\frac{3}{4}$ to 2 in., inclusive, is given in Table 1.

The meter test tabulations shown in Tables 2–6 are taken from the official meter test records of the Los Angeles Dept. of Water and Power. These meters are listed in numerical sequence according to their factory serial numbers, and are not specially picked samples. They are new meters which were recently purchased under the standard water meter specifications of the department and represent several

different makes. All test flows were accurately measured through rate-of-flow indicators, and accurately calibrated 10-cu.ft. test tanks were used for all tests.

These tests speak for themselves—and conclusively—about the possibility of high registration accuracy. Nor has the department been required to pay a premium rate in order to obtain this degree of registration accuracy, for the price paid is comparable to meter cost figures of other large water utility systems throughout the country.

Much credit for obtaining this high degree of meter efficiency must be given to the meter manufacturing companies for the refinement of their manufacturing processes and controls, such as precision machining, special tooling and the improved assembly methods employed.

TABLE 2

Test of $\frac{5}{8} \times \frac{3}{4}$-in.-Positive Displacement Meters

Meter No.	Rate of Flow gpm.		
	¼	2	16
	per cent accuracy		
1	100.0	100.0	100.0
2	100.0	101.0	100.1
3	100.0	101.0	100.2
4	100.0	100.0	100.3
5	100.0	101.0	100.0
6	100.0	101.0	100.0
7	100.0	100.5	99.9
8	99.0	101.0	99.7
9	100.5	101.0	100.2
10	99.0	101.0	100.5
11	99.7	100.0	99.7
12	99.8	100.0	99.8
13	99.9	100.2	99.8
14	99.9	101.0	100.0
15	100.0	100.2	99.7
16	100.2	100.5	99.8
17	100.3	100.5	99.8
18	99.8	100.0	99.7
19	99.6	100.2	99.9
20	100.0	100.5	100.1

Assigning Meters to Jobs

The type of meter used for various kinds of water service can have an appreciable effect upon the revenues of the water system, as all meters are not adaptable to all conditions of water use found in a water system.

TABLE 3

Test of $\frac{3}{4} \times 1$-in. Positive Displacement Meters

Meter No.	Rate of Flow gpm.		
	½	3	21
	per cent accuracy		
1	100.0	101.2	99.8
2	100.0	100.9	99.4
3	100.5	101.4	100.2
4	99.8	100.9	99.8
5	99.9	101.0	99.6
6	101.0	101.7	100.2
7	100.0	101.4	100.2
8	100.2	101.6	100.0
9	100.9	101.7	100.0
10	101.0	101.9	100.2
11	100.6	101.9	100.1
12	98.6	101.0	100.0
13	100.0	101.8	99.8
14	100.0	101.3	100.4
15	100.6	101.3	100.2
16	100.4	101.5	99.8
17	100.0	101.1	100.0
18	100.3	101.0	100.0
19	100.8	101.4	100.0
20	99.4	100.7	100.0

As an illustration, the manner of water use for irrigation is decidedly different from the water use in an industrial plant. A higher rate is usually charged for commercial and industrial water than for water used for irrigation.

The meter best suited for the average domestic service, in which the water is generally used for household

purposes at reasonably low rates of flow, but which normally carries a high per unit charge, is the positive displacement meter capable of accurately recording extremely low rates of flow while incurring a minimum loss of head.

Minimum head loss in all types of meters is important if the consumers are to receive full benefit of main pressures under conditions of sustained heavy demand, particularly if property pipes are old or undersized, and every additional pound of head loss adds to the consumer's water supply problem. Positive displacement meters have a high degree of efficiency and durability in all sizes from ⅝ to 2 in., within the limitations of their minimum and maximum flow rates.

For large commercial and industrial services, the compound meter is best adapted because of its flexibility in recording accurately both low and high flows up to the maximum capacity of the meter. This type of meter incorporates a positive displacement type section for sensitive registration of low flows and a current type section for the high flows, with a compounding valve which normally directs the flow from one section to the other, depending upon the rate of flow.

This element of flexibility makes possible a high degree of over-all registration accuracy in a meter supplying an industrial plant in which frequent high rates of flow for industrial purposes alternate with the very small flows supplying drinking fountains or

TABLE 4

Test of 1-in. Positive Displacement Meters

Meter No.	Rate of Flow *gpm.*		
	½	5	43
	per cent accuracy		
1	100.0	100.0	100.0
2	100.0	100.0	99.5
3	100.0	100.0	100.0
4	100.0	101.0	100.0
5	99.0	100.0	100.0
6	100.0	100.0	100.0
7	100.0	100.0	99.6
8	100.0	100.5	99.5
9	100.0	100.0	100.0
10	100.0	100.0	99.5
11	100.0	100.0	100.0
12	100.0	101.0	100.0
13	100.0	100.0	100.0
14	100.0	102.0	100.0
15	100.0	100.0	100.0
16	100.0	100.5	100.0
17	100.0	101.0	100.0
18	99.5	100.0	100.0
19	100.0	100.0	100.0
20	100.0	100.0	100.0

TABLE 5

Test of 1½-in. Positive Displacement Meters

Meter No.	Rate of Flow *gpm.*		
	1	7	85
	per cent accuracy		
1	98.0	101.0	100.0
2	100.0	102.0	99.0
3	100.0	102.0	100.0
4	99.0	102.0	100.0
5	98.0	102.0	99.0
6	98.0	101.0	98.0
7	98.0	101.0	100.0
8	99.0	102.0	100.0
9	98.0	101.0	100.0
10	99.0	101.0	99.0
11	100.0	102.0	100.0
12	99.0	102.0	100.0
13	99.0	102.0	100.0
14	99.0	102.0	100.0
15	98.0	102.0	100.0
16	100.0	102.0	100.0
17	99.0	102.0	100.0
18	97.0	102.0	100.0
19	99.0	101.0	100.0
20	98.0	102.0	100.0

wash basins, or stemming from leaks. This type of meter is manufactured in 2 in. and larger sizes and is readily adaptable to single or battery installations.

For certain types of industrial services, in which there is a constant high rate of flow, and for irrigation services, the current or velocity type meter gives the most satisfactory performance. The current or velocity type is especially adapted to serve irrigation supplies, in which continuous high rates of flow are required with a minimum loss of head. The current meter is a sturdy, compact unit, and is generally manufactured in 3 in. and larger sizes.

TABLE 6

Test of 2-in. Positive Displacement Meters

Meter No.	Rate of Flow *gpm.*		
	1¼	10	125
	per cent accuracy		
1	98.0	100.0	99.0
2	99.0	100.0	100.0
3	99.0	100.0	100.0
4	99.0	101.0	100.0
5	99.0	100.5	100.5
6	98.0	100.5	100.0
7	98.0	100.0	100.0
8	99.0	100.0	100.5
9	99.0	101.0	100.0
10	99.0	101.0	100.0

Conclusion

As the impact of the increased cost of labor and materials, as well as a heavy demand for improved consumer service, is felt by the water works utilities throughout the country, it is inevitable that the industry must strive for greater efficiency in water production and operational methods in order to reduce costs. In many areas where water is already scarce and additional supplies are difficult to procure, the elimination of water waste is an immediate problem.

Complete metering of water systems throughout the country, together with the application of adequate rates, offers an objective approach and the only satisfactory solution to many of these problems.

The Pacific Coast states of California, Oregon and Washington are at present attempting to meet an unprecedented postwar influx of population which is far in excess of any predictions for a postwar shift of our nation's population. This enormous increase in population naturally places heavy demands on many of the present water works facilities in these states, and often makes necessary an immediate expansion and development program. Water meters cannot meet this entire problem, but they can do their share by effectively discouraging water waste, both through leaks and overconsumption, thereby relieving some of the pressure on overburdened systems.

The American Water Works Association is taking a timely step forward in sponsoring a program of public relations intended to increase consumer confidence and develop a better understanding of water works problems, as well as a deeper appreciation of the dependency of our community and city life upon an adequate and dependable water supply. The publicity slogan: "Silent Service Is Not Enough" indicates the inadequacy of the spirit of the entire water works industry in the past, when the consumers and citizens of our communities were not given an opportunity to become interested in their water utilities, nor to appreciate the vital part they played in sustaining life, nor their importance as an equity

towards the future development of a community.

The water works industry should be proud of its position in the community and city life of our country and especially of the important influence which it exerts in community development. To maintain this position of leadership, and to merit the confidence of the general public, the water works industry must prove that it has alert management which is continuously striving to develop more efficient methods and better equipment to be used in the operation of its facilities for the benefit of its consumers.

Water meters are good—but good water meters are better. Consumer-relation problems are more easily met if efficient water meters are employed, as the up-to-date water utility is always ready and eager to prove to its customers that water meters are accurate and efficient, and are incorporated in a water system for the customers' protection, thus developing the confidence of the customers in the efficient operation of their water utility.

Yes, water meters earn their keep—but good water meters keep on earning: dollars and consumer confidence and respect.

Regulation of Water Rates in Quebec

By A. Larivière

A paper presented on Apr. 16, 1947, at the Canadian Section Meeting, Montreal, Que., by A. Larivière, Vice-President, Provincial Transportation and Communication Board and Professional Engr., Quebec, Que.

THE end of the last century and the beginning of the twentieth—a period when the province was making rapid progress in all fields of activity—saw the birth of a large number of public utility companies in the communities and municipalities of Quebec. Those who were in charge of the administration of the province at that time soon realized that a commission or board would be required to exercise control over these utilities to prevent abuses, to provide the public with adequate services at fair and reasonable rates, and to furnish a means of securing redress for any cause of complaint which might arise.

With this object in view, the Quebec Public Utilities Commission was created in 1909 (9 Ed. VII, ch. 16). The powers of this body were quite limited, and, strange to say, it had no jurisdiction over water and sewer systems. This oversight was corrected by amendments to the law in 1911 (1 Geo. V, ch. 14) for the water utilities and in 1922 (12 Geo. V, ch. 26) for the sewer utilities.

In 1920, the act was completely revised, and the name of the commission changed to Quebec Public Service Commission (10 Geo. V, ch. 21); and in 1926, important amendments and additions were introduced (16 Geo. V, ch. 16).

Powers of Provincial Board

In 1939 the Provincial Transportation and Communication Board took over the jurisdiction and powers formerly exercised by the Quebec Public Service Commission over all privately owned and certain municipal public utilities, except those providing electric power and light. The same board is now in existence with the same jurisdiction, although from 1940 to 1945 it was replaced by the Public Service Board, which had jurisdiction over all public utilities, including those providing electric service.

The board, as constituted by law, is composed of four controllers or members, one of whom is president and another vice-president. The chief office of the board is located in Quebec, with a branch office in Montreal.

The board sits in all judicial districts of the province, although most of the sittings are held in the cities of Quebec and Montreal. At its disposal is a general secretary, a chief engineer and a staff of engineers with assistants and clerks.

The board has jurisdiction over any person, partnership, company or corporation (other than a municipal or school corporation) and its lessee, trustee, liquidator, sequestrator or receiver, operating, administering or controlling

a public service for the transmission of telegraphic or telephonic messages, for the conveyance of passengers or goods by railway, tramway, navigation, autobus, taxi or delivery car, for the hiring of pleasure motor vehicles driven or to be driven by the person hiring same or his appointee, for the production, transmission, distribution or sale of gas, steam, water, heat, light or power, produced otherwise than by electricity, and for a water works or sewer system.

A municipal corporation operating a public water works or sewer system wholly or partly outside of its territory is under the jurisdiction of the board for the operations conducted beyond its geographic limits.

The board may make an inventory of the property of any owner of a public service and carry out investigations of the financial structure, books, methods of accounting, rates, receipts, profits, salaries and, in general, all the operations of such owner. In so doing, the board may have access to any place where the public service or part of the service forming the object of an inventory or of an investigation is situated, make a full examination of the premises, work, rolling stock and other property therein, and take cognizance of any books, plans, specifications, drawings and documents whatsoever that it may deem useful to consult.

The prices, rates and rentals charged by any owner of a public service must be fair and reasonable. Upon its own initiative, or at the request of any interested party and after investigation, the board may amend the prices, rates and rentals demanded by the owner of a public service in order to render them fair and reasonable. It is illegal for an owner to demand or to receive prices, rates or rentals other than those fixed by an order of the board, and any amount paid in excess of the prices fixed by the board may be reclaimed by the person who paid it or by his representative or assigns notwithstanding any agreement or stipulation to the contrary.

At the request of any interested party, the board may cancel or alter any contract or regulation of a public service, if it is established that the conditions of the contract or regulation are abusive. The board may impose upon the owners of public services the obligation of adopting any measure or reform tending to improve their services and it may regulate conditions affecting health and safety in public services. The decisions of the board on any question of fact within its jurisdiction are final and without appeal.

A permit from the board is required to begin the construction, operation or administration of a public service in the province. In granting a permit, the board states the conditions deemed useful or necessary for the protection of the rights and interests of the public in general. The board may cancel or amend an authorization at any time, if it is deemed expedient and in the public interest. Also the owner of a public service must obtain the authorization of the board to cease or interrupt his operations or to extend or amend his service.

Whenever the board decides that the owner of a public service has the right to enter a municipality for the purpose of placing therein the rails, poles, wires, pipes, conduits or other appliances upon, over or under any property belonging to the municipal corporation and whenever the owner cannot come to an agreement with the municipality on the use of the property or the terms or conditions of the use or of the continuance of the use, the board has exclusive jurisdiction to hear and decide

the dispute, and may permit the use or continuance of use of the property upon such terms and conditions as it may prescribe. The same power may be exercised by the board whenever the owner of a public service is authorized to extend his service into new territory and cannot come to an agreement with the appropriate municipal corporations for the use of their properties, and the board may grant the use of such properties regardless of any law or contract granting to any other person or company exclusive rights in the territories or their parts. The board also has jurisdiction to hear and decide any dispute which may arise between a municipal corporation and the owner of a public service over the carrying out of the terms and conditions laid down by the board under the authority of the two preceding powers, and it may change such terms and conditions whenever it deems it in the public interest.

The board may, upon the demand of a municipal corporation or of any interested party and after investigation, order an owner of a public utility to extend service in the municipality in which he already carries on his service, and may fix the conditions of such an extension, including the cost of all necessary works, which the board may apportion between the owner and the municipality. In exercising its right of supervision over owners of public services, the board may also make such ordinances as it considers necessary governing the quality of the service, equipment, apparatus, extension of works or systems, message routes, reports to be made, rules, regulations, conditions and practices respecting rates, prices and any other matter within its jurisdiction. It may likewise make such ordinances as it may deem necessary for the public safety and advantage and the faithful performance of any contract, charter or franchise entailing the use of public property or rights.

Regardless of any general law or special act to the contrary, every merger, cession or sale of a public service effected by the purchase of all or part of the capital stock or assets of another public service or otherwise, is subject to the approval of the board and may only take effect from the date fixed in the order attesting such approval. When an owner of a public service applies to the board to obtain the exchange of a service with another owner of a similar service, the board may make such ordinance as it may deem to be in the public interest for the connection of the lines, transmission of messages, right of passage for cars and other facilities, and may determine the compensation and the other conditions for such exchange of services.

The water utilities in the province may be divided into two groups:

1. Those which belong to municipal corporations, over which the board has no jurisdiction, except for such parts as are operated outside municipal limits

2. Those which are privately owned by companies, commercial corporations or individuals, over which the board has full jurisdiction.

The first group comprises 255 systems owned by 24 cities, 82 towns and 149 other municipal corporations. Of these 255 systems, 90 extend outside the boundary of the municipal corporations and 26 are supplying water at their limits to neighboring municipalities. The population served by the municipal corporations, excluding those residing and served outside of their

territorial limits, is estimated at 2,188,600.

Municipal Systems and Rates

A few typical examples of rates in force in municipally owned systems may be cited:

Montreal. The water tax is proportionate to the annual rental value and is equal to 7½ per cent for the ordinary customer and 12 per cent for hotels of less than 20 rooms and for inns and restaurants. The general rate for water supplied by meter is $1.15 per 1,000 cu.ft., with a minimum, per quarter, of 1.875 per cent of the annual rental value. The city sells water to a few adjoining municipalities at the rate of 15¢ per 1,000 gal.

TABLE 1

Domestic Water Rates in Sherbrooke, Que.

		Rate
For the first faucet:	4 rooms	$5.00
	5 rooms	6.00
	6 rooms	7.00
	8 or more	8.00
Each addnl. faucet		1.00
Baths:	first	3.00
	addnl.	1.00
Water closet:	first	2.00
	addnl.	1.00
Hose		3.00

Quebec. The water tax is equal to 0.5 per cent of the municipal valuation, plus $2.00 per water closet. The city also sells water by meter to a few customers at various rates, depending upon the conditions, and to two adjoining municipalities at 15¢ per 1,000 gal.

Sherbrooke. The water rates, per quarter, for domestic service in the city of Sherbrooke are given in Table 1. To religious and educational institutions, the water is sold by meter at $0.099 per 1,000 gal. The rate for industrial and commercial purposes is given in Table 2.

Chicoutimi. The schedule of flat rates shown in Table 3 is in effect in the city of Chicoutimi. Water is also sold by meter for domestic or commercial purposes at 20¢ per 1,000 gal. and for industrial purposes at a rate per 1,000 gal. of 20¢ for the first 100,000 gal. and 10¢ for additional usage plus a meter charge which varies with the meter size. The industrial rate also applies to the sale of water to the neighboring village of Rivière du Moulin.

TABLE 2

Commercial and Industrial Rates in Sherbrooke, Que.

Minimum Charges, per Quarter

Size of Meter	Charge
in.	
½	$3.30
¾	4.95
1	7.42
1½	11.00
2	16.50
3	22.00
4	33.00
6	49.50

Meter Rates, per Quarter

Consumption	Charge
1,000 gal.	*¢ per 1,000 gal.*
Up to 100	22.0
Over 100, up to 200	19.8
Over 200, up to 500	17.6
Over 500, up to 1,200	12.1
Over 1,200, up to 2,000	11.0
Over 2,000, up to 3,500	9.9
Over 3,500, up to 6,000	8.8
Over 6,000	7.7

Hampstead. In the completely residential town of Hampstead, a suburb of Montreal, water is sold by meter at a rate of 35¢ per 1,000 gal. There is no minimum or meter rental charge.

Victoriaville. In the town of Victoriaville in the Eastern Townships, a special water tax of 10¢ per $100 of municipal valuation is imposed, in addition to the charges listed in Table 4. Special rates are imposed upon certain commercial establishments.

Private Systems and Rates

The second group of water utilities over which the board has jurisdiction comprises 645 privately owned systems, to which should be added 90 municipally owned systems partly operated outside of municipal limits. The capital investment in these systems is estimated at $13,400,000; the annual gross revenues at $1,660,800; the number of customers at 58,900; and the population served at 320,000.

TABLE 3

Water Rates in Chicoutimi, Que.

	Charge
First tap	$21.00
Each addnl. tap	2.00
Shower	3.00
Bath room (complete)	3.00
Water closet (alone)	3.00

It may be seen that the board must deal with a large number of rather small systems, the average number of customers served being a little more than 80 per system. Very few of the privately owned water utilities sell water by meter, except to commercial or industrial customers. A few examples of typical annual rates charged by utilities over which the board has jurisdiction may be cited:

Donnacona. The town of Donnacona is served by the Donnacona Paper Co., which charges $10.00 for the first tap and $5.00 for each additional one. Baths and water closets cost $3.00 each.

Montmagny. The general service rate charged by the Corp. d'Aqueduc de Montmagny is $18.00; each bath, water closet and hose costs $3.00. Barber shops are charged $7.50; garages $24.00; stores $15.00; restaurants $7.50, and so on

Maskinonge. This village is charged a rate that varies with the assessed value of the property The minimum rate, for valuations of $300 or less, is $5.00; the maximum, for valuations over $800, is $8.00. In addition, $3.00 is charged for each water closet and $1.00 for each hose. The first animal brings a charge of $1.00; each additional one, $0.50.

St. Eustache. Customers in this village, served by the General Utilities Corp., pay $5.00 plus $0.50 for each $100 of the assessed valuation of their property up to a limit of $3,000, beyond which the rate is $0.25 per $100 of valuation. Each bath or water closet costs $2.00. Horses are charged $2.00 each; cows, $1.00.

Herbertville. This parish is served by the village of Herbertville Station. The rates for general farm service depend upon the farm acreage. A charge of $30 is made for a farm of 50–75 acres, $40 for 76–100, $50 for 101–150, and so on up to $65 for 251–300 plus $5 for each additional 50 acres. A charge of $3 is also made for each bath or water closet.

Exercise of Board Authority

The law requires that the rates of the public service shall be fair and reasonable, and any complaint about rates—or any application for their revision—implies that this prescription of the law shall be followed. What is meant by "fair and reasonable rates"? In the author's opinion, it means that the

public utility shall, in return for the fair and reasonable service which it is bound to give, receive gross revenues enabling it to pay an interest on the capital usefully, prudently and really invested in its enterprise, to provide for the depreciation or renewal of its system and to pay the costs of operation and administration.

The rate of return allowed on the investment has seldom been less than 5 per cent or more than 6 per cent, although extremes may have gone down to 4 per cent or up to 7 per cent in special circumstances.

The so-called straight line method of depreciation is generally adopted. The rate of depreciation varies with the material used, as well as—for piping, particularly—with the nature of the soil and the characteristics of the water. Generally, the rate of depreciation allowed for pipe will vary between 3 and 4 per cent for wood-stave pipe, between 2.5 and 4 per cent for galvanized iron pipe and between 1 and 2 per cent for cast-iron pipe. A lower rate of depreciation is allowed on concrete or brick structures, and a higher rate is granted for machinery such as pumps and motors.

TABLE 4

Water Rates in Victoriaville, Que.

	Charge
First tap	$7.20
Each addnl. tap	1.00
First water closet	2.00
Each addnl. water closet	1.00
Each bath	1.50
Each horse	2.00
Each cow	1.00

The cost of administration and operation is relatively easy to determine, especially for a public utility which has been in operation for a few years, as an examination and analysis of the records of two or three normal years will disclose the amounts spent for maintenance, repairs, operation and administration. Experience has shown that, for small gravity systems, such costs generally vary from 3 to 4 per cent of their value. When water has to be pumped, filtered or chlorinated, the cost of such operations must necessarily be taken into account.

The right of the public utility to fair and reasonable revenue implies that it shall supply consumers with a service adequate both in quantity and quality. On occasion, when public services were recalcitrant and refused or neglected to comply with orders for the improvement of their systems, the board temporarily reduced their rates as a penalty. Such a procedure may seem illogical, as to deprive the owner of a water works of a portion of his revenue may seem to make it more difficult for him to comply with the board's orders. This seldom-used practice, however, has proved to be quite effective. Is it really illogical, after all, to refuse a public utility its full revenue if it does not give full service?

When a complaint about rates or an application for an increase or revision of rates is received, the board, after due notification to all interested parties, holds a public sitting. Before or sometimes after the hearing, the case is referred to the engineers of the board for an investigation, study and report. The public utility must establish the value of its system and produce its books, showing its assets and liabilities as well as statements of its revenues and expenses for any period required by the board; it is also required to file any other information which the board or its engineers may deem necessary

for a study of the case. When the order of the board is rendered, copies are served upon all interested parties, and the decision is effective on the date specified in the order.

Mention was made previously of an article of the law which authorizes the board to cancel or alter any contract or regulation of a public service if it is established that the conditions of such contract or of such regulation are abusive. A reference to the jurisprudence created by the board in the application of this article may be of interest.

A town situated in the northwestern section of the province had granted a franchise for a period of 20 or 25 years to an individual for the operation of a water works in its limits. The relations between the municipal authorities and the owner of the water system had not been amicable during the term of the franchise, due to the poor service given by the owner. One year before the expiration of the franchise, the municipal authorities decided to begin the construction of a water works of their own, in order to be ready to supply service to their rate-payers when the franchise ceased. As soon as they made a move to accomplish this purpose, however, they were menaced with legal proceedings, due to the existence of a clause in the franchise forbidding the municipality to build a water works as long as the franchise existed. An order of the board declared the clause abusive, and the municipal corporation was able to proceed with the construction of its system.

In another case, the board cancelled a contract between a municipality near Montreal and a water company, because the latter, notwithstanding the repeated orders of the board, neglected to perform the work required to improve its service. By so doing, the municipality was given a clear road to construct a system of its own and to remedy the situation.

In a few cases, this article of the law was used to put aside unfair low rates incorporated into long-term franchises—rates under which the water utility was unable to operate any longer without either going into bankruptcy or neglecting the maintenance of the system to such an extent that the service would become inadequate.

On one occasion, the board had before it a hotly contested case in which a municipal corporation had paid a sum of $16,000 for which it was supposed to receive water in perpetuity from a water company; in the same case, some farmers had paid amounts varying from $150 to $250 and even $300 in order to receive water forever. The amounts so collected were used to build the system. Everything went fairly well for the first few years when the pipes were new and did not require much maintenance or repair. With time, however, conditions changed, and, as there was no revenue, a succession of bankruptcies occurred until some one applied to the board for a solution. After a lengthy investigation, the board came to the conclusion that the municipal corporation and the farmers had received more in service than they had paid for in money, even allowing them an interest on their investment; and that the only way to insure the continuation of water supply was to order them to pay in the future for service received. The board therefore fixed the rates to be paid by all users of water. On a question of law, this decision of the board was referred to the Court of Appeals, which upheld it.

The jurisdiction and powers conferred upon the board have been mentioned, but in virtue of other laws its jurisdiction extends to a great variety of other matters too involved to enumerate. There are two, however, which are of interest because they deal with water service and rates.

Until recently, the municipal corporations which are governed by the municipal code were required to hold a referendum before they could increase the water rates charged to their rate-payers. An increase in rates or taxes is always unpopular, even if necessary, and it sometimes happened that rate-payers would vote against a by-law authorizing the council to increase rates. Under an amendment to the municipal code, municipal corporations now have the choice of submitting the proposed increase of water rates for approval either to the rate-payers by referendum, as formerly, or to the board.

Another very important jurisdiction conferred upon the board by another law is that mentioned in articles 61 and 62 of the Quebec Public Health Act, which read as follows:

61. Whenever, after investigation, it is established by the Minister:

First. That it is necessary or advantageous for two or more municipalities or parts of different municipalities, on account of their geographic situation and for the sake of their future development, to possess jointly certain drainage works or works for the supplying or the distribution of water, wholly or partly, or to connect two or more systems of such works whether for reasons of public health or well-being or for reasons of economy; or

Second. That any portion whatsoever of the inhabited territory of a municipality has no works or system of drainage or water distribution, or does not benefit in an effectual and satisfactory manner from the existing works or systems; or

Third. That the drainage and water distribution works of any municipality have become insufficient for the protection of the public or of property, or for purposes of public health and well-being

The Minister, one or more of such municipalities or any interested elector who is the owner of real estate may apply to the Provincial Transportation and Communication Board, which, after investigation and after consulting the Minister, may order what is necessary to be done, choose the source of water supply, determine the nature of the works to be executed, whether new constructions, alterations, improvements, extensions or connections, order their execution, fix the delay and the manner of their execution, give all the necessary orders, and, without restricting the general meaning of the above expressions, in the case of paragraph 1, order that the execution, maintenance and operating be done jointly by all the interested municipalities or wholly or partly by a single municipality, or that the existing works in one or more of such municipalities be used, or that the service be wholly or partly supplied by one municipality to another or others, and may apportion the cost of such works and the expenses of maintenance and operation thereof, and determine the manner of payment of the compensation, periodical or otherwise, payable for the use of the works or for the service supplied by one municipality to another or to other municipalities. R.S. 1925, c. 186, s. 61; 21 Geo. V, c. 78, s. 1; 23 Geo. V, c. 73, s. 2; 4 Geo. VI, c. 11, s. 12; 5 Geo. VI, c. 22, s. 16;

62. Any municipality ordered to carry on any work under section 61 is authorized, in order to comply with the order of the Provincial Transportation and Communication Board, to take the necessary amount from its general funds not otherwise appropriated, and, if necessary, to borrow the said amount, without being bound to observe the formalities regard

ing loans required by the laws by which it is governed, and without affecting its borrowing power. R.S. 1925, c. 186, s. 62; 4 Geo. VI, c. 11, s. 12.

The jurisdiction conferred upon the board by these articles of the Quebec Public Health Act are often found very useful in insuring that parts of municipalities without service be supplied with water or sewer services. But by far the most important applications of these articles were in the district of Montreal, where the board ordered the execution of sewerage works of great magnitude in order to drain parts of the territory of several outlying municipalities. It may be well also to mention the Little St. Peter River sewer, the cost of which was estimated in 1929 at over $7,000,000 to be used and paid for by 10 municipalities. Another important sewer system, the construction of which was ordered by the board in co-operation with the Provincial Bureau of Health, comprises a main sewer interceptor along the Black River for a long distance, with lateral tributary trunk sewers on one side and overflow sewers on the other; this system will eventually drain all the watershed lying between Mount Royal and the Back River. The cost of all these works, including a sewage purification plant, was estimated in 1930 at $7,500,000.

In all of its activities—its control over water rates, the way the control is exercised and the work done in co-operation with certain branches of the provincial administration, such as the Provincial Bureau of Health, the Fire Commissioner and so on—the aim of the board is to insure that the public shall receive the best possible service at rates which are fair and reasonable for all concerned.

Numerical Rating System for Municipal Water Supplies

By O. E. Brownell

A paper prepared from talks given on Sept. 14 and 18, 1946, at the Fargo, N.D., and Duluth, Minn., Regional Meetings of the Minnesota Section by O. E. Brownell, Public Health Engr., Minnesota Dept. of Health, Div. of Sanitation, Minneapolis, Minn.

NUMERICAL rating systems to portray status, trends or conditions are now applied in many different fields. For example, numbers are used to rate milk supplies, the stock market, the cost of living and the cost and volume of construction. Over many years the water works man has been interested in the possibility of applying numerical ratings to water supply systems. Because of the differences between surface and ground water supplies, the large number of sanitary defects possible and the varying degrees of hazard they introduce, and the various methods of approach to the problem that can be used, the formulas and systems devised have been somewhat complicated. It suffices to say that numerical rating systems for water supplies have not been universally adopted.

One of the earlier systems of numerical rating of water supplies was proposed by E. Sherman Chase in 1932 (1). This paper contains a list of references dating back to 1917. More recently, John R. Baylis discussed the U.S. Public Health Service standards in a paper (2) that points the way for numerical ratings without setting up values for items. The Tennessee Dept. of Health has a rating system described by R. P. Farrell in a paper published in 1940 (3). Texas also has a water supply rating system, which it has used since 1936.

The Minnesota Dept. of Health approached the problem in 1938 by rating supplies according to a predetermined list of sanitary defects, and later used two rating sheets—one with an appropriate list of defects for untreated ground water supplies and another with a listing suitable for both surface and ground water treated supplies. Scoring was accomplished by deducting points for defects from an arbitrary figure large enough to accommodate the values assigned to all known defects. Because of the large number of sanitary defects that may occur in a water supply, this method was considered too cumbersome. It could not be applied so that the desired single score sheet could be used.

Present Rating System

The elementary units into which a water supply system may be divided —with the operator himself considered as one—are now used as the basis for the rating, instead of the list of defects. Although the operator is not actually a part of the system, he determines how the system will function

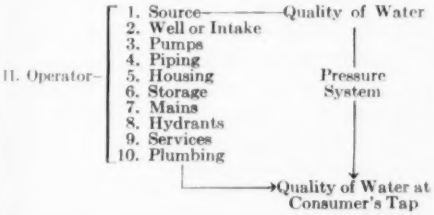
and his knowledge, training, experience and application result in protection or hazard to the consumer. For the purposes of rating the safety to the consumer, he is therefore considered a part of the system.

According to the general concept of a water supply used to simplify and clarify the present rating system, the major elementary divisions of a water system comprise the following:

1. The source (surface or ground water).
2. Prime moving equipment (to move the water forward from the source, through the distribution system, to the consumer).
3. The distribution system.
4. The standard of operation and qualifications of the operators.

These four major divisions are subdivided into only 11 component parts, and, in contrast, there are about 150 known sanitary defects which may so affect these parts as to cause contamination of the water supply.

The 10 physical parts of the system are listed below under the control of the eleventh "part," the operator. To this list are added the quality of the water at the source, in which pollutional loading or bacteriological safety is considered, and the quality of the water at the consumer's tap.



Since contamination may move from one part of the system to another, or may spread from the source to the entire system in the path of the flow of water, it follows that sanitary defects affecting the source or pumps are more serious than similar defects in the distribution system. Accordingly, larger values are assigned to the source and pumping equipment, with decreasing values being applied as the flow of water reaches the consumers' taps. The total number of points for a perfect score, pro rated and weighted over the parts of the water system, is 100 (Fig. 1). The component parts are then rated according to the various sanitary defects found to be affecting the quality of the water handled or processed by the unit.

To illustrate, on a simple water supply system, a pump is one of the fundamental units of the system—the one which moves the water from the source forward to the distribution system. Seven points are allotted to the pump for a perfect score. Numerous sanitary defects may be associated with pumps, such as improper drainage on the base plate, oil lubrication of submerged bearings, improperly protected vents and improper priming equipment. Under the present system, the pump is given a maximum rating of 7, and the defects are evaluated and deducted from this value according to the hazard to or the effect on the sanitary quality of the water delivered from the pump.

Sources

Raw surface waters may vary in pollutional loading from near zero to 20,000 or more coliform organisms per 100 ml. The water must be given treatment that will offset the loading if full credit is to be given. For a ground water source in a proper location, nature may be considered to have provided adequate treatment. If ground waters are subject to contami-

MINNESOTA DEPARTMENT OF HEALTH

DIVISION OF SANITATION

Sanitation Rating of.....Water Supply

Owner.....Date.....

	Perfect Score	As Found	As Recommended	See Recommendation No.... in Attached Report
(*A*) *Source*				
Bacteriological safety / Adequacy of treatment	30			
Physical quality	2			
Chemical quality	4			
Biological quality	2			
Adequacy of quantity	2			
SUB-TOTAL	40			
Hazard adjustment factor deducted	0			
TOTAL	40			
(*B*) *Prime Moving Equipment*				
Well or intake	8			
Pumps	7			
Piping arrangement	5			
Reservoirs	7			
Equipment housing	3			
SUB-TOTAL	30			
Hazard adjustment factor deducted	0			
TOTAL	30			
(*C*) *Distribution System*				
Street mains	5			
Building services	2			
Plumbing	3			
Hydrants	1			
Storage	4			
Pressure	2			
Tapwater quality	3			
SUB-TOTAL	20			
Hazard adjustment factor deducted	0			
TOTAL	20			
(*D*) *Operation and Operators*				
Control of system	5			
Condition of system	3			
Training and experience	2			
SUB-TOTAL	10			
Hazard adjustment factor deducted	0			
TOTAL	10			
GRAND TOTAL AND RATING	100			

Grade A: Ratings from 90 and upward. Indicates a high degree of safety.
Grade B: Ratings from 80 to 90. Indicates a reasonable degree of protection.
Grade C: Ratings from 70 to 80. Indicates that there are serious hazards in the supply that demand attention. Any grade below "C" portrays a dangerous condition of the supply from which serious consequences can develop. Emergency measures for immediate protection of the supply are recommended under these circumstances and prompt action should be taken to provide a permanent remedy of the defects.

FIG. 1. Rating Sheet for Minnesota Water Supplies

nation, the pollutional loading is determined and rated in the same manner as for surface waters.

For example, assume a surface raw water loading of 10,000 coliform organisms per 100 ml., and chlorination with storage to be the only treatment provided. The chlorination would rate only 5 points out of 30, or one-sixth of the treatment needed. Without filters or coagulation, plankton would not be removed, and no credit could be given for biological quality, incurring a further deduction of 2 points. Assuming the rest of the system to be perfect, it is apparent that without a factor of safety of at least 1 (as discussed in the *Manual of Water Supply Sanitation* (4)), the rating would be between 65 and 75, which is too low to be acceptable, and indicates that the supply is in dangerous condition.

Where more than one well is in use, it is necessary to evaluate the proportion of time each well is used and the degree of hazard affecting each well. If a well is very close to a sanitary sewer, it receives no credit. Some credit may be given for a well which is more than 30 ft. from a sewer and is used, perhaps, only as a stand-by, especially if the sewer itself is only a floor drain or building sewer from a pump station, which is seldom used.

The rating for any particular item will lie between full credit, given if the item complies entirely with the requirements set forth in the *Manual of Water Supply Sanitation,* and no credit, the penalty for complete violation of the requirements. In evaluating a sanitary hazard, four essentials should be kept in mind: (1) the location of the hazard on the system, (2) the degree of contamination involved, (3) the frequency of occurrence of the hazard and (4) the number of persons subjected to the hazard. For example, a cross-connection to a rainwater pipe or cistern in a residence on a dead end would affect only a small portion of the distribution system, probably only the persons living in the residence; the occurrence would be seasonal, and the degree of contamination light. The deductions for such a connection would be small. The hazard exists, however, and should be removed. In contrast, assume a raw water by-pass around filters, with a blow-off to a trunk sewer. All consumers would be subjected continuously to a high degree of hazard. Such a sanitary defect in "piping arrangement" would warrant a further deduction of points under the heading "hazard adjustment factor."

Rating systems occasionally do not portray extreme or unusual conditions and, in order to take care of such situations, this hazard adjustment factor provides flexibility to help make the rating more nearly reflect these special conditions. It is rarely necessary to use the factor in rating the average water supply. To illustrate further, assume a system perfect in all respects except for a 10-point hazard at the source and the absence of trained operators (7 points) for controlling the system. The deduction would total 17 points. This condition would earn a rating of 83, or just under an acceptable 85. A 10-point hazard at the source with a competent experienced operator in control does not present any serious condition; without proper control, however, these 10 points fail to show the seriousness of the hazard, or the necessity for proper control. The factor of safety would be reduced and the quality of the water in the distribution system would really be subject to greater deterioration than can be shown by the usual way of rat-

ing. Under such conditions, an additional 10-point deduction for the source and a 3-point deduction for tap water quality would be warranted. This would result in a rating of about 70, which more nearly shows the true condition of the supply.

Prime Moving Equipment

Prime moving equipment includes everything necessary to move the water from the source forward into the distribution system. Many complicated combinations of stand-by pumping equipment located both above and below ground may be encountered. Each piece of equipment is allotted its share of the credited value. If there are no reservoirs, the 7 points for reservoirs may be omitted and the proper proportion of 30 points taken. It is sufficiently accurate to give full credit of 7 points if there are no reservoirs, and full credit may also be given if there are no pumps and the water flows by gravity from the source into the distribution system. The equipment housing includes the kind and condition of the floor, floor drainage and doors which may obstruct drainage.

Distribution System

A distribution system rarely is rated as perfect, for only a brand new system, in a region where sewers have not yet been constructed and service connections to plumbing have not been made, would be free from sanitary defects. Distribution systems practically never rate full credit because there are so many sewer and water pipe crossings at street intersections where additional leak-prevention equipment has not been installed, and usually some water and sewer pipes have been laid together in the same trench. Old existing plumbing has been found to be about 75 per cent hazardous. If no plumbing ordinance is in effect, and assuming that some of the plumbing may be satisfactory, a credit of 0.5 may be given. A satisfactory ordinance can be rated 1.5, a system of permits and records 0.5 and active enforcement an additional 0.5. Most plumbing ordinances in Minnesota not patterned after the State Plumbing Code are not entirely satisfactory. The average distribution system rates 15 or 16 points. With low pressures, poor analytical results and an improperly protected tank, the rating may be as low as 10 points.

Operators and Operation

Many municipalities are not large enough to warrant the employment of a full-time water works superintendent and the operation of the water plant is undertaken by the power plant superintendent. Some of the surface water supplies do not have proper laboratory control. It is necessary to determine whether the supervision and control provided in such systems is sufficient for the particular conditions and credit should be given accordingly. Background training, attendance at water works schools, and licensing of operators aid in grading operators.

Advantages of Numerical Rating

The advantages of the numerical rating schedule, when made in conjunction with a report on a field investigation, may be outlined:

1. The condition of the parts of the system is listed and evaluated as an inventory, indicating the degree of seriousness of each defective item.

2. A program of measures to improve defective conditions is suggested by the relative values of the items.

3. Ratings show from time to time whether improvement is being made on an individual supply.

4. Ratings on a group of supplies may be weighted according to the consumer populations, and progress by counties or states as a whole may be indicated.

5. Ratings tend to clarify and make written reports more understandable to persons who do not have technical training. A rating sheet, read in conjunction with a report of investigation which contains specific recommendations for correction of defects, indicates the relative importance and advantage of carrying out the recommendations.

6. This system of rating is not so technical or complicated that it cannot be understood by the average water superintendent.

It is possible for water supplies to lose grade through the deterioration of materials, addition of improperly located and constructed wells and the employment of improperly trained and inexperienced personnel.

For many years past, the Minnesota Dept. of Health has met difficulty caused by misunderstanding of the use of the term "approved" when applied to public water supplies. An approval is generally interpreted by the owner or the public to mean 100 per cent safe. Many supplies have minor defects but are still considered reasonably safe. If such a supply is "approved," it would appear that the department did not find or had overlooked the defects —or, having found them, considered them of no importance. Understandably, it is difficult to bring about improvements after having "approved" the supply.

The numerical rating system shows that a reasonably safe water supply, rated at 85 or more, may still have sanitary defects that should be corrected. Even a grade of 90, entering the Grade A group, can be improved upon. Thus the numerical rating portrays what the department has been unable to express with the "approved" term, and does away with the misunderstandings involved.

The data required to rate a water supply, most of which must be provided by the water works superintendent, are not difficult to verify. There may be disagreement on the rating of various items, but the rating system provides a basis on which further study of the variances usually brings about an accord and better understanding. The rating system is one that may be used by the water works superintendent himself, with beneficial results. It is expected that, as the rating system is more generally used, proficiency in its use will be acquired. As a result, improvements and uniformity will be made both in the water supplies and the system for rating them. The experience of the department indicates that a numerical rating system has many advantages which far overbalance the disadvantages, and that it is practicable to apply such a system in the sanitary control of water supplies.

References

1. Chase, E. Sherman. Numerical Rating of Public Water Supplies. Jour. A.W.W.A., **24**:1288 (1932).
2. Baylis, John R. Water Quality Standards. Jour. A.W.W.A., **32**: 1753 (1940).
3. Farrell, R. P. Rating and Approval of Public Water Supplies. Jour. A.W.W.A., **32**:1986 (1940).
4. Brownell, O. E. *Manual of Water Supply Sanitation.* Minnesota Dept. of Health (1941).

Discussion

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It is gratifying that the usefulness of numerical rating systems for public water supplies continues to be recognized.

The Minnesota rating system appears to lay particular emphasis upon the bacterial analyses of raw and treated waters and upon the physical characteristics of the water works structures and equipment. The author also penalizes water supplies for defects which only under the most unlikely combination of circumstances would result in a supply of dangerous quality.

If the object of a rating system is to express in a roughly quantitative way the probability of a water supply's causing disease, then care should be taken to avoid the too free use of imagination on remote contingencies. For example, oil lubrication of submerged bearings is a possible but extremely improbable source of infection—certainly the chances of contamination are less than one in a hundred. If such sanitary trivia are to be evaluated, the maximum number of points a water system might receive should be in the order of a million rather than a hundred. It is pertinent to observe that, among the millions of people in upstate New York, who are served by hundreds of public water supplies which would fail to approach a Minnesota score of 100, there were but 53 cases of typhoid fever in 1946.

It seems to this writer that the author's "hazard adjustment factor" leaves too much leeway to the prejudices of the scorer. In the example cited in the paper, the penalty imposed for a given hazard at the source is increased if the water system is without proper supervision. This seems like an unnecessary double penalty. A hazard remains a hazard with or without proper supervision of the water system. The penalty for lack of supervision should be charged against protective measures, and not against a hazard already penalized, it is presumed, adequately.

The writer agrees that rating systems are useful for public water supplies, although he is inclined to feel that the Minnesota system overstresses minor and insignificant defects of the distribution system and understresses the potential hazards of raw water sources. The Minnesota approach seems to be the puritanical one of "How bad you are!" and not the charitable one of "How good you are!"

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; Corr.—Corrosion; I.M.—Institute of Metals (British); P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British).*

WELLS AND GROUND WATER

Protection of Underground Water From Sewage and Industrial Wastes. ARTHUR PICKETT. Sew. Wks. J. **19**:464 (May '47). Los Angeles County, Calif., contains 44 cities, approx. 100 unincorporated communities and thousands of industries and farms. Water distributed by more than 500 water companies obtaining water from wells, springs and streams and from Owens and Colorado R. aqueducts. Flood control dams divert virtually all runoff from mountains into natural underground reserviors. These formed from prehistoric lakes and valleys filled with sand and gravel washed from adjacent mountains. Their capac. totals 3.7 mil. acre-ft. in first 100′ of gravels. Reservoirs underlie much of coastal plain where most pop. concd. Many instances of poln. of wells, particularly from industrial wastes. No community 100% sewered; many homes and industries depending on sub-surface sewage disposal. County ests. future expenditures over $60,000,000 for treatment plant extensions, sewers and outfalls. New regulations require approved sewage disposal plants for all industries and periodic inspections of operations.—*F. J. Maier.*

The Geology of the Honolulu Ground Water Supply. HAROLD S. PALMER. Board of Water Supply, City and County of Honolulu. 1946. 55 pp. Clear, non-technical description of geologic nature and hydraulic working of main ground water system of Honolulu area. Origin of ground water discussed and dependence on rainfall demonstrated. Behavior of ground water, especially that of artesian water, discussed in detail, as well as its special behavior on islands, where "Ghyben-Herzberg lens" formed because of equil. between fresh and salt water. Geologic history and structure described, together with relation of water-bearing lavas and generally water-tight sedimentary cap rocks along broad belt bordering edge of island. Combination of these factors causes existence of artesian fresh waters below cap rock, which are fed by rain on mountains where lavas outcrop and which are floating on salt water with transition zone of mixed fresh and salt water. Due to heavy pumpage, water level in this artesian basin fell 2′ to 9′ in 35 yrs., with corresponding rise of salt water level of about 40 times amt. of this recession. Quant. of fresh water stored therefore greatly reduced, and data given indicating increase in salt content of water in some wells. Salt content depends to some deg. on depth of well and could be reduced in 1 well by plugging lower section. Ever-present danger of contamg. fresh ground water by salt water requires conservation measures in pumpage and replacement of wells by tunnels in which fresh water can be skimmed. Booklet richly illustrated with clear diagrams and maps.—*Max Suter.*

Notes on Steady Underground Flow. CHARLES JAEGER. Schweiz Bauzeit. (Swiss; in French) **65**:152, 163 (Mar. 22, 29, '47). Ground water flow under water table conditions considered special case of free flow. Flow produces surface which depends on 5 variables (dimensions), i.e., amt. of flow, energy head, actual head, total vol. in movement, and distance. Math. expressions given for boundary conditions, Davey's Law and potential relations. For steady conditions there exists critical height for which changes in flow, energy or vol. in movement are zero.

So far no vigorous integration of differential equations obtained possible. Approximations are given for 2 cases: Dupuit's soln. with vertical equipotentials of velocities and Vibert's soln. with circular equipotentials of velocities, circles joining at right angles water surface and base of aquifer (Fig. 1). While Dupuit's formula gives max. flow for complete drawdown, Vibert's formula, $Q = 2\pi Kyx\delta$ (where K is permeability, x distance from axis, and y height above bottom of aquifer of a point on water surface at which angle of slope is δ in radians) does not give such an unreasonable result. Vibert's theory is shown to have good correlation with actual measurements, and it is shown how this theory can be used to calc. water surface, permeability and max. discharge. Its principle can be applied also to many other ground water problems, such as drainage channels or pipes, flow in inclined or irregular aquifers, wells not penetrating full aquifer, or for groups of wells.—*Max Suter.*

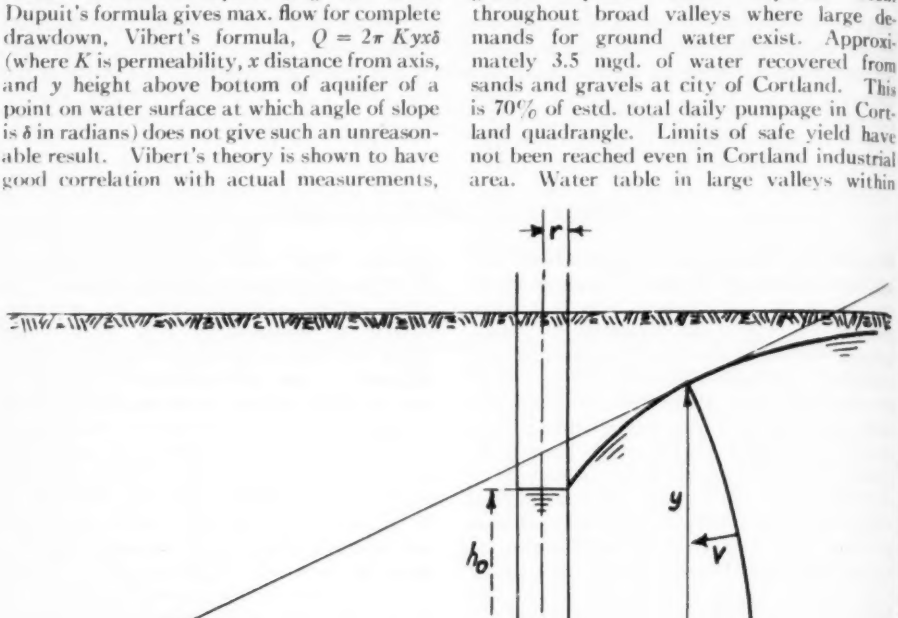

FIG. 1. Determination of Steady Underground Flow

Progress Report on Ground Water Conditions in the Cortland Quadrangle, New York. E. S. ASSELSTINE. Bul. GW-16, U.S. Geological Survey and New York Water Power & Control Com., Albany, N.Y. ('46). Bedrock and thin mantle of glacial till in uplands have relatively low permeability. They generally furnish, however, adequate water supplies for domestic and livestock purposes and in places yield moderate quants. of water for industrial and public supply. Chief water-producing formations in Cortland area are sand and gravel deposits. These deposits occur throughout broad valleys where large demands for ground water exist. Approximately 3.5 mgd. of water recovered from sands and gravels at city of Cortland. This is 70% of estd. total daily pumpage in Cortland quadrangle. Limits of safe yield have not been reached even in Cortland industrial area. Water table in large valleys within few ft. of surface at most times during year. Anals. of water samples collected from wells in bedrock and unconsolidated deposits show relatively small amts. of dissolved mineral constituents. They also show that there is some increase in hardness and iron content with depth and that water from gravels tends to have greater noncarbonate hardness than water from bedrock. Differences in qual. of ground water that was obtained from different kinds of water-bearing formations and from different depths, however, very small. Low, constant temp. and generally good qual. of water in different geologic formations make ground water suitable for wide range of uses.

In addn., long record of substantial pumpage from several wells in sand and gravel deposits, including Cortland public supply wells, indicates that economy of area dependent in considerable part on availability of ground water supply.—*Ed.*

Progress Report on Ground-Water Resources of the Southwestern Part of Broome County, N.Y. R. H. BROWN & J. G. FERRIS. U.S. Geological Survey and New York Water Power and Control Com., Jamica, N.Y. (1946). Areas selected for initial study are those in which pumpage from ground water storage already heavy. This report presents information gathered to date for southwestern part of Broome County where so-called "Triple Cities" of Binghamton, Johnson City and Endicott rapidly developing one of largest concns. of ground water pumpage in state. Included in report is brief geologic history of area with discussion of principal geologic formations; records of 58 wells and 30 borings; pumpage figures for principal ground water supplies, hydrographs showing variations in ground water levels, and pptn. and runoff data, all for 8-yr. period; typical chem. anals. of water samples collected from 21 wells and 5 surface sources; and ltd. amt. of data on ground water temps. Examn. of assembled data suggests present development of ground water in this area at critical times approaches 40% of total available supply, while on avg. it approximates 20–25%. Data further suggest genl. location and extent of preglacial valleys and some of areas in which satisfactory supplies of potable ground water known to exist. Report indicates that further development of ground water supplies in the area should avoid vicinities of existing well fields where wells already badly overcrowded and should take advantage of certain other selected and as yet undeveloped parts of area where existing natural features suggest presence of satisfactory ground water supplies. Report concludes by pointing out some obvious phases of investigation requiring addnl. work and study to furnish information now entirely missing or only partly known.—*Ed.*

Induced Infiltration Supplies Most Productive Well Field. RAPHAEL G. KAZMANN. Civ. Eng. **16**:544 (Dec. '46). Well field on bank of Wabash R. near Terre Haute, Ind., owned by ordnance works consists of 6 Ranney-type wells spaced at 2000′ intervals. Source of water artificially induced infiltration from river through very productive aquifer composed of sand, gravel, and boulders, with total thickness of about 100′. For 2-yr. period during war field yielded avg. of 72 mgd., or 12 mgd. per collector. Collectors consist of reinforced concrete caissons of 13′ inside diam. Approx. 2′ and 6′ from bottom of caissons tiers of portholes. Total of 1700′ of 8″ slotted well casing, having 0.38 sq.ft. of openings per lin.ft., projected from portholes into aquifer in lengths ranging from 50′–250′. Above each caisson is pump house with three 600-hp., 3-phase, 60-cycle elec. motors, each driving deep well turbine pump capable of lifting 5000 gpm. against 400′ of head. As source of water is Wabash R., specific capac. of collectors, in gpm./ft. of collector drawdown, varies considerably with temp. of river water, being much higher in summer. Lab. tests indicate that collector water bacteriologically safe without any kind of treatment. —*P.H.E.A.*

Correlating Flood Control and Water Supply, Los Angeles Coastal Plain. WARREN N. THAYER & GEORGE B. GLEASON. Proc. A.S.C.E. **72**:697 (May '46). Some addnl. data have been obtained on growth and dissipation of large ground water mound at spreading grounds of Rio Hondo Coastal Basin. Under ideal conditions, spreading of water to replenish ground water carried on from Jan. 3–23, '46. 6 days after spreading started, ground water rose 18′ to meet spreading water in basin No. 4. About 3500′ downstream from basin No. 4, ground water also rose 18′ but did not meet spreading water in basin because initial el. of ground water had been farther below ground surface. These facts verify statements made in paper that normal depth to ground water important criterion in selecting spreading sites. Min. depth for economic spreading in coastal plain of Los Angeles County 20′–25′. Possible reduction in pump lift mentioned as another benefit of spreading. Value of spreading discussed from standpoint that only part of spread water conserved and intended purpose might be accomplished more effectively or at lower cost by other means.—*P.H.E.A.*

Artificial Recharge of Ground Water on Long Island, N.Y. M. L. BRASHEARS JR. Economic Geology, **51**:503 (Aug. '46). In '33, water table in large area in western Long Island below sea level, and potability of ground water threatened by inflow of sea water. To prevent further overdevelopment,

New York State Water Power & Control Com. has required that water pumped from new wells for cooling and similar purposes be returned to the ground. During summer of '44, over 200 recharge wells and several recharge pits were returning water at combined rate of about 60 mgd. Also in operation were several large recharge pits which return storm sewer runoff in Nassau County. Water returned to glacial beds from which most of it is pumped, but in places it percolates into underlying Cretaceous formations. Well drillers have developed recharge wells capable of returning as much as 1000 gpm., many of them having been in operation for over 5 years without failing. Recharge pits dug in coarse glacial gravels capable of returning about 1 mgd./acre of exposed surface. Legal requirement that water pumped for cooling be returned to aquifer has caused gradual decrease in net withdrawal of ground water but has increased actual use. Hence rise in water levels has occurred in critically overdeveloped area. Water levels reached lowest stage at end of '41 and have recovered slowly since then. However, water levels still far below sea level in many places and sea water continues to move inland in areas of heavy pumping.—*Ed.*

Horizontal Type Well Increases Ground Water Yield. CECIL C. COFFIELD. W. W. Eng. **100**:346 (Apr. 2, '47). Caisson constr. of Ranney well using horiz. screens in water-bearing stratum increases yields, avoids flood damage.—*Ed.*

Water in the Sahara. MICHEL RAINEAU. Wtr. & Wtr. Eng. (Br.) **49**:390 (July '46). About 1000 yrs. ago, Moslems of Ibathi sect, to escape persecutors, chose tableland 480 mi. s. of Algiers, known as Mzab. This is true desert region where it rains only every 7 or 8 years. Ibathis dug wells 50–115′ deep to irrig. narrow valleys. Today there are 7 small cities in Mzab. New water miracle, thanks to geological science, taking place. Artesian well sunk at gates of Ghardaia to depth of 1300′. Water rises within 180′ of ground surface; pumped rest of way. Now there is fountain in every street in town. Two other artesian wells being sunk.—*H. E. Babbitt.*

Boring for Water in South Africa. ANON. Wtr. & Wtr. Eng. (Br.), **49**:408 (July '46). Dept. of Irrig. embarked on 5-yr. plan to increase number of its boring machines. About 3,000 applications for water boring outstanding. Louis Esselen, member National Veld Trust, said: "We already have approx. 45,000 boreholes, and, judging by latest reports, Dept. of Irrig. and private contractors will sink 36,000 boreholes during first 5 yr. after war. Underground water level falling, and hundreds of vleis and springs have gone." —*H. E. Babbitt.*

Correlation of Ground Water Levels and Precipitation on Long Island, N.Y. C. E. JACOB. New York Wtr. & Control Com. Bul. GW-14. Paper designed to "justify use of cumulative departure from progressive avgs. for correlating pptn. with ground water levels and with 'ground water flow' in streams, thus combining in a sense idea of cumulating departures with idea of using progressive avgs." Pamphlet profusely illustrated with charts, maps and tables.—*Ed.*

Ground Water in the High Plains of Texas. W. N. WHITE, W. L. BROADHURST & J. W. LANG. U.S. Geological Survey Water Supply Paper 889-F, pp. 381–420. The High Plains of Tex., noted for abundant ground water supply, extend from northern boundary of Panhandle southward about 300 mi., and from N. Mex. line eastward for avg. distance of about 120 mi., occupying area of about 35,000 sq.mi. Most of usable ground water found in Ogallala formation, sandy deposit, 200′ to 300′ thick, lying at or near surface. Most of surface of High Plains underlain by sediments that are cemented with calcium carbonate, called caliche. Those deposits probably prevent deep penetration of surface water over most of High Plains. Principal areas of ground water recharge apparently depressions occupied by intermittent ponds, sandy stream beds, and sand dune areas. Before withdrawal of ground water started, ground water reservoirs in approx. equil. Greater part of natural dischg. occurred through springs and seeps along eastern escarpment of High Plains and bluffs on either side of Canadian R. Total natural dischg. estd. to be at rate of 25,000 to 30,000 acre-ft. per yr. Irrigation from wells in this area started 30 yr. ago near Portales, N. Mex. Periods covering constr. of wells listed. Total amt. of water withdrawn during these periods roughly estd. in acre-feet. Water levels in about 600 observation wells measured at intervals from month to year. Irrigation practiced during all 4 seasons. Winter slack season and comparison of measurements made in late winter or early spring in successive years most informative. There has been

general decline in water table in principal pumping dists. in past few years. In area of about 300 sq.mi., southeast of Plainview, water table had avg. decline of about 1.5′ from Mar. '38–Mar. '40. In Hereford water table had avg. decline of about 1.0′ from Mar. '38–Mar. '40.—*P.H.E.A.*

Supply of Artesian Water in Queensland. ANON. Surveyor (Br.) **104:** 662 (Nov. 2, '45). Portion of Queensland west of Great Dividing Range almost wholly dependent for continuance of its pastoral industry on water obtained from bores tapping vast underground reservoir of Great Artesian Basin. This basin underlies parts of Queensland, New South Wales, South Australia and Northern Territory, and has area of 550,000 sq.mi. Length north and south is 1200 mi. and it is 1100 mi. at widest part. Flow of water steadily declining and pastoralists have been forced to drill addnl. bores. Total flow of all bores in Queensland now 230 mgd. (Imp.). Most generally accepted theory advanced to account for artesian beds is that rain water enters exposed edges of porous sandstone beds and percolates through them across basin. When bore put down and pierces aquifer, distention of aquifer nearby gradually relieved by flow of water expelled by weight of overlying rock. At first, flow from bore greater than rate at which water can flow from intakes. Pressure and flow gradually decrease to amt. that can be supplied by replenishment from intakes. Water usually distributed by open drains. This method has many disadvantages. There are losses from evapn. and seepage, estd. at 10,000 gal./mi. in 24 hr. Less than 5% of water distributed for stock actually used by stock. Use of artesian water for irrig. has been suggested. Over 22,000 gal. (Imp.) of water must be used to apply 1″ of water per acre. Accepting 48″ per yr. as requirement, total dischg. of basin, at present rate of flow, would be sufficient for only 80,000 acres. Qual. of water must also be considered as avg. qual. of artesian water generally unsuitable for irrig.—*H. E. Babbitt.*

CHEMICAL ANALYSIS

A Nomograph for the Conversion of Results of Water Analysis. I. YU. SOKOLOV. Zavodskaya Lab. (U.S.S.R.) **12**:879 ('46). Nomograph designed to convert results of gravimetric anal. of water into mg.-equiv. to within 0.01–0.02 mg.-equiv. It consists of 9 vertical parallel lines corresponding to Na^+, Mg^{++}, Ca^{++}, HCO_3^-, Cl^-, SO_4^{--}, CO_3^{--}, NO_3^- in mg./l. and hardness in German degs. A common mg.-equiv. vertical line is drawn in center of nomograph. Examples of calcns.: carbonate hardness from HCO_3^-; total hardness from Ca^{++} and Mg^{++}; salt content from one of its ions; salt-forming components from salt content.—*C.A.*

Quality of Surface Waters of the United States, 1943. C. S. HOWARD & S. K. LOVE. Geological Survey Water Supply Paper 970, U.S. Dept. of Interior. 180 pp. Paper gives tables of mineral anals. of streams in Florida and Georgia in S. Atlantic slope and eastern Gulf of Mexico basins, of streams in Colorado, New Mexico and Texas in the Lower Mississippi Basin, and of streams in New Mexico and Texas in western Gulf of Mexico basin for period from Oct. 1, '42 to Sept. 30, '43. Similar tabulations of records of chem. anals. given for Colorado R. and its tributaries. Most of anals. are of 10-day composites of daily samples collected for a year at a sampling point. Each table gives avg. stream dischg. at sampling point for corresponding sample period. Summary given of anals. from '25 to '43 for streams in Colorado R., Pecos R. and Rio Grande Basins.—*P.H.E.A.*

The Microdetermination of Total Carbon Dioxide (Dissolved). TADASHIRO KOYAMA & KEN SUGAWARA. J. Chem. Soc. (Japan) **65**:703 ('44). Handy app. for detn., in open field, of total CO_2 dissolved in natural water described; 250 ml. of water brought into vessel contg. zinc globules. On addn. of H_2SO_4, CO_2 obtained by decompn. of carbonate brought into another vessel contg. known quant. of $Ba(OH)_2$ by means of H produced. By titrating excess $Ba(OH)_2$ with HCl, CO_2 can be detd.—*C.A.*

The Determination of Cyanides. T. R. HASELTINE. Wtr. & Sew. Wks. **94**:187 (May '47). Gives methods of treatment and detn. of cyanides in wastes.—*Ed.*

Chemical Investigations of Hot Springs. [IX.] A New Colorimetric Method for the Determination of Fluorine. HISATERU OKUNO. J. Chem. Soc. Japan **63**:23 ('42). To 250 ml. of alum soln. (Al = 0.1–1.5 mg.)

are added 5 ml. of satd. $(NH_4)_2CO_3$ soln. and 2–10 ml. of 0.1% hematoxylin. Mixt. allowed to stand for 15 min., and then 5 ml. of acetic acid (1:2) added. Reddish-violet coloration takes place. When this colored reagent added to soln. contg. F, decolorization takes place in the order: reddish-brown, brown, yellowish brown according to F content. By use of this reaction, very delicate test and method of colorimetric detn. of F devised. By choosing quant. of alum and hematoxylin properly, various reagents obtained. By adjusting quant. of reagent, colorimetric detn. carried out for F content of 0.001 mg./50 ml. This method can be applied equally well for F and SiF ions. Other impurities ordinarily found in water do not interfere with this method.—*C.A.*

The Distribution of Fluorine in Potable Waters in New South Wales and Tasmania. R. L. REID & N. D. MARTIN. Med. J. Australia, **33**:121 ('46). Anal. of 80 samples of surface water in New South Wales and Tasmania showed that 74 of these had F content of 0.2 ppm. or less; of 13 ground waters examd., 9 contained 0.5 ppm. or more. Signif. of these findings discussed in relation to chronic endemic dental fluorosis and dental caries.—*C.A.*

Fluorine Adsorptiveness of Tricalcium Phosphate. HOWARD ADLER. U.S. 2,417,462 (Mar. 18, '47). If $Ca_3(PO_4)_2$ pptd. in F-contg. H_2O, F removed down to 1 ppm. Effective concn. 200 ppm. $Ca_3(PO_4)_2$ to each part F. In one of illustrating expts. 500 ml. H_2O contg. 3 ppm. F treated with milk of lime to give 6000 ppm. $CaCO_3$ hardness. Then $Ca_3(PO_4)_2$ pptd. by addn. of H_3PO_4. Filtered H_2O had 7.01 pH and contained 0.2 ppm. F and 60 ppm. hardness. Instead of pptg. phosphate, H_2O may be percolated through bed of $Ca_3(PO_4)_2$. Adsorptiveness then lower but phosphate may be regenerated by washing with dil. NaOH.—*C.A.*

Iodine in Drinking Water. C. H. PAPE. Ingeniøren (Denmark) **53**:26:K.30 ('44); Chimie & Industrie (Fr.) **52**:66 ('44). Waters contg. chlorides and iodine found in many places in Denmark, not only near sea, but often at great distance from coast, proving that source of these substances not always sea water. Contents of chlorine of 3.15 mg./l. and of iodine of 0.42 mg./l. have been found. In U.S. and in Holland, iodine sometimes added to water supplies.—*W.P.R.*

Iodine Content of (Various) Waters. M. I. KARGER & A. V. CHAPYZHNIKOV. Trav. Lab. Biogeochim. Acad. Sci. U.R.S.S. (U.S.S.R.) **7**:51 ('44). Widespread survey made of iodine content of various bodies of water (lakes, rivers, tributaries, reservoirs, etc.) in Karelian, Burat-Mongolian, Kresnoyarsk, and Moscow regions. Anals. made on 62 bodies of water. Iodine contents varied from 0 to 1.8 μg. per l. In 2 cases it was as high as 2.6 and 4.3 μg. per l.—*C.A.*

Determination of Magnesium in Water. DANIEL J. BENGOLEA & FORTUNATO D. AMATO. Rev. Obras Sanitarias Nacion (Arg.) **20**:71 (Feb. '47). Study of spectrophotometric procedure for Mg^{++} detn. by titian yellow showed appreciable variation in results with temp. deviations greater than ±5° C. from that at which calibration curve obtained and low recoveries in presence of Al^{+++} and SiO_2 in concns. above 0.5 and 20 ppm. resp. Aluminum interference elimd. by adjusting pH between 6.5–8.5, if necessary, and filtering sample through slow filter paper. Attempts to reduce SiO_2 concn. by adsorption in flocculent ppts. unsuccessful. SiO_2 interference compensated for by use of 4 calibration curves obtained with solns. covering the range from 0.1 to 1.1 mg. Mg^{++} and contg. 1, 2, 3 and 4 mg. SiO_2 per 100 ml. Iron, phosphate and fluoride in concns. below 0.5, 5, and 3 ppm. resp. did not interfere. Ca^{++} up to 140 ppm. and Cl^- up to 5000 ppm. did not affect results. Modified procedure as follows: Place 60 ml. filtered sample, or smaller vol. contg. from 0.1 to 1.1 mg. of Mg^{++} made up to 60 ml. with distd. water in 100 ml. volumetric flask. Add 1 ml. *N* H_2SO_4, 10 ml. 1% starch soln., 5 ml. $CaCl_2$ soln. (1 ml. = 3 mg. Ca^{++}), and 10 ml. 0.05% titian yellow soln. Immediately add, drop by drop with continuous agitation, 10 ml. 2*N* NaOH soln. Fill to 100 ml. mark with distd. water, transfer to glass-stoppered 250 ml. Erlenmeyer flask and agitate vigorously 5 minutes. Transfer portion to spectrophotometer tube and compare transmittancy against blank using a wavelength of 530 mμ. (approx.). Blank prepd. with same reagents and procedure outlined for sample, good for one day. Mg. of magnesium in test portion obtained from appropriate calibration curve to compensate for amt. of SiO_2 in sample. Starch soln. prepd. daily and filtered. Modified procedure rapid and sufficiently accurate for routine Mg^{++} detns.—*J. M. Sanchis.*

Nickel and Cobalt in Mineral Springs. I. Nickel Content of Acid Vitriol Springs in Japan. NOBUYUKI TANAKA. Bul. Chem. Soc. Japan **18**:201 ('43). By using Pulfrich photometer and extending Ni dimethylglyoxime from ammonium citrate soln. with chloroform according to Rollet's method Ni contents of several springs detd. Richest in Ni was Wakesui, Okayama Prefecture, and avg. was 0.0024% of total residue. **II. Nickel and Cobalt Contents of Tentoku Mineral Spring, Saga Prefecture.** *Ibid.* 365. Richest content of Ni and Co in Japan found: 9.38 mg. Ni/l. and 2.19 mg. Co/l. **III. Nickel Contents of Some Mineral Springs and Their Deposits.** NOBUYUKI TANAKA. Bul. Chem. Soc. Japan **19**:177 ('44). Ni and Fe contents of 3 acid hydrogen-sulfide springs, 2 carbonate springs, 1 simple cold spring, and Ikaho spring (the other type in Japan) detd., and atomic ratios of Ni to Fe calcd. Ni detd. colorimetrically by measuring color of Ni dimethylglyoxime compd. Ni and Fe content of service water of Tokyo also detd. 20 times. Deposits formed from Ikaho spring analyzed. Ocherous deposit proved to consist mainly of noncryst. Fe_2O_3. X-ray powder photographs of calcareous deposits of 2 kinds showed that one was $CaCO_3$ of calcite type and other of aragonite type. Ni and Fe contents of deposits also detd. Suggested that there might be some relation between atomic ratio of Ni to Fe, Fe content, and pH of spring. From distr. of Ni between spring water and deposit, shown that sea water shows greatest atomic ratio of Ni to Fe.—*C.A.*

A Chloride and Oxygen Analysis Kit for Pond Waters. R. B. DEAN & R. L. HAWLEY. Pacific Sci. **1**:108 ('47). Portable app. for electrometrically testing pond water for Cl and O described. Cl anal. depends upon fact that potential of Ag electrode changes rapidly when all Cl ions have been pptd. by Ag ions. O detd. by electrometrically detg. end-point of titration of I by $Na_2S_2O_3$, I having been liberated from iodide ions by manganic ions formed by O acting on manganous hydroxide. Up to 25 g./l. of Cl can be detd. to within 0.06 g./l. and up to 20 ml./l. of D.O. can be detd. to within 0.1 ml./l.—*C.A.*

Application of Liquid Amalgam to Volumetric Analysis XXVII. Determination of Dissolved Oxygen in Water. SABURO ISHIMARU & TIKAFUSA TANAKA. J. Chem. Soc. (Japan) **63**:1708 ('42). Std. soln. of K_2CrO_4 reduced by means of Zn-Hg, and resulting Cr^{++} used to reduce oxygen dissolved in water. Amt. of Cr^{++} consumed detd. by titration with Fe alum. Procedure carried out in app. excluding air.—*C.A.*

Simplified Method for Measuring Dissolved Oxygen in Streams. CHARLOTTE E. WILCOX. Trans. Illinois State Acad. Sci. **39**:67 ('46). Colorimetric method proposed by Isaacs and Gilcreas for detg. D.O. consists in shaking sample of water with amidol (diaminophenol-HCl) and K citrate soln. for 30 min. and comparing color obtained with std. $CoCl_2$ soln. Isaacs and Gilcreas found that yellow color developed, which had to be allowed for by adding $K_2Cr_2O_7$ to test. Wilcox traced this yellow color to nitrites present in distd. water used in making up comparison soln. Usually there is only trace of nitrite involved, and dichromate can be omitted. When nitrites present to extent of 2 ppm. of N, correction should be used. Modified method preferable to std. Winkler method, because it is simpler, speedier, and can be used in field. —*C.A.*

Hydrolysis of Dehydrated Sodium Phosphates. R. N. BELL. Ind. Eng. Chem., **39**: 136 (Feb. '47). References in literature to use of molecularly dehydrated phosphate in water treatment numerous. Useful life of these compds. depends on their ability to withstand hydrolysis in aq. solns. Many attempts have been made to measure rate at which compds. rehydrate (hydrolize), but methods cited gave insufficient information on products formed or of the mechanics of rehydration. Recent methods for detg. triphosphate and pyro-phosphate rendered possible, in presence of each other and in presence of other phosphates, to make fuller study of hydrolysis. Methods of procedure of study detailed and progress in conversion of phosphates noted together with time-in-hours graphs. Temp. greatly affected rate of hydrolysis.—*Ed.*

Determination of Traces of Silver in Mineral Waters by the Dithizone Method. KADZUO KURODA. Bul. Chem. Soc. Japan **17**:419 ('42). Volumetric detn. of Ag in presence of Fe studied. Found that if Fischer's dithizone method applied after removing Fe by NH_4OH and $(NH_4)_2CO_3$ soln., Ag can be detd. down to 5 γ per l. 11 mineral springs in Japan tested by this method. Presence of Ag detected only in hot springs of Sukayu. Values were 12–15 γ per l. Arc spectro-

graphic detn. of Ag also studied. Intensity change of spectral lines of Ag with Ag content qualitatively detd. by prepg. Ag solns. of various concns. This spectrographic method gave 10 γ per l. as Ag content of Sukayu.—*C.A.*

Dithizone Method for Determining Zinc and Copper in Natural Waters. KURT BUCH. Finska Kemistsamfundets Medd. (Finland) **53**:1/2:25 ('44). Equil. const. of reaction $H^+ + \frac{1}{2}ZnD_2 \rightleftharpoons HD + \frac{1}{2}Zn^{++}$ is 2.26×10^{-3} where symbol HD represents dithizone, and corresponding const. for copper dithizonate (**I**) is 1.01×10^{-7}. These conts. apply to heterogeneous soln. but are calcd. on total quants. as if it were one phase. pH at 50% decompn. 4.59 for zinc dithizonate and 0.32 for **I**. To assure complete extraction of metals from aq. soln. by CCl_4-dithizone reagent pH should be above 5.2 when Zn detd. and above 1.5 when Cu detd. Application to anal. of waters of the Baltic Sea showed Zn contents between 8 and 23 γ/l. and Cu contents between 1.5 and 7.8 γ/l. except where local contamn. occurs.—*C.A.*

Vanadium, Chromium and Molybdenum Contents of Some Mineral Springs in Japan. KADZUO KURODA. Bul. Chem. Soc. Japan **17**:213 ('42). V, Cr, and Mo contents of 17 hot springs in Japan detd. Relations between each and pH of spring traced. The greater the pH, the more V and Cr the springs contained, while no regular relation found for Mo. Noted that mean value of each element of hot springs in Japan far less than Clarke's number of the element.—*C.A.*

The Change of Chemical Composition of Hot Springs Under the Influence of Tide. KADZUO KURODA. Bul. Chem. Soc. Japan **17**:381 ('42). Influences of tide upon such properties as output; evapn. residue; Cl^-, SO_4^{--}, Na^+ and Ca^{++} concn.; pH; and temp. of hot springs at Ito studied. In one spring that is just 50 m. from the sea, Cl^- concn. greater in flood tide than in ebb tide. In 2 other springs that are about 100 m. from sea, found that concns. of above max. at ebb tide and min. at high tide, while outputs of the springs were parallel with height of the sea. At half moon, chem. compn. less influenced by tide. Temp. of springs scarcely changed by tide. Increasing Cl^- concn. in first case interpreted as some mixing of sea water with spring water. Suggested, in latter 2 cases, that not sea water but underground water that is more dil. than spring water might have entered spring below ground under pressure of high tide. **II. Further Studies of Hot Springs at Ito.** *Ibid.* 435. Change of chem. compn. of 3 hot springs at Ito further studied. In 2 hot springs that are more than 300 m. from sea, tide seemed to have no influence upon temp., pH, and Cl^- content of water. In one other spring, about 70 m. from sea, max. output and temp., and min. Cl^- concn. reached 1 or 2 hr. after flood tide. This spring was intermittent and no hot water came up for about 3 hr. during ebb. Noted that Fukutomi's theory holds for above phenomenon.—*C.A.*

HYDROLOGY AND CONSERVATION

Report on Tests With the Divining Rod. FRITZ GASSMAN. Monatsbulletin (Swiss), **27**: 12 (1947). Tests were made under direction of geophysicist to determine whether movement of rod in hand of diviner due to physical causes. 16 experienced diviners worked independently over 7 selected fields geologic and structural properties of which known to geophysicist alone. Results obtained by each diviner plotted exactly by individual observers and measurements, under seal, compared only after all tests completed. Maps then plotted indicating no. of diviners finding each location sensitive. Several zones indicated by groups of diviners, each zone by different group. None of existing pipes, including 22″ water main, found by any of diviners, but mains indicated by them where none existed.—*Max Suter.*

The Divining Rod is Practical Hydrology. V. ZATLOUKAL. Gas, Wasser, Wärme (Austria) **1**:143 (June '47). Author had opportunity to compare action, behavior and estimates of divining rod carriers with studies and observations of well yields, pumping expts. and ground water levels. During the pumping expts. the diviners followed rather closely a pattern to be expected when ground dewatering takes place. Two or more diviners followed similar paths, but not completely the same. Repetition after 2 years, however, showed similar results. Constr. of test wells did not show increased yields. Several

diviners' results on ground water levels showed a complicated pattern, but agreed in general with the actual conditions. The conclusion is reached that the diviner reacts through unknown causes; his reactivity varies from time to time and place to place and is aided by auto-suggestion. Experience shows that the diviner may support the hydrologist in location of wells, dewatering, drainage projects and in determining the porosity of soil. The diviner usually has no knowledge of geology and hydrology, which should be left to the expert, and the expert should use the diviner as an "instrument" who is not faultless.—*W. Rudolfs.*

Radio Prospection for Water and Minerals. J. CECIL MABY. Surveyor (Br.), **105**:431 (May 31, '46). Prospecting by means of divining rod ancient and widespread craft. Scientific investigators assured it is veridical art. Results from stimulation of sensitive's body by objective physical force; every indication that latter is high-frequency wave radiations of electromagnetic type and natural origin. High percentage of success obtainable by operator who trains himself in new technics taking into account local geology and other factors. Laboratory tests with artificial sources of energy show human beings give reflex tonic changes when electrical oscillations induced in them. Flowing water boosts natural intensity of (radioactive) field. Correlation between instrumental data and human physiological responses nearly perfect in sensitive and skillful subject. To det. specific nature of hidden object, dowser carries in bone hand small specimen of material he is seeking. In all tests best operators repeatedly successful. Automatic recording instruments of electromagnetic type needed to replace human by something more consistent and mechanical in response. Instrumental research must proceed in parallel to physical theory.—*H. E. Babbitt.*

Geophysical Prospecting and Water Supply Problems. J. MCG. BRUCKSHAW. Wtr. & Wtr. Eng. (Br.) **49**:507 (Sept. '46). Magnetic method, seismic method, and resistivity method applied to problems of interest to water engrs. Resistivity method depends on electrical resistivity of rocks involved. If 2 metal spikes driven into ground and joined to source of electrical energy, current will flow through ground. When ground not uniform in resistivity, current flows through paths whose shape changes with electrode spacing. Expts. can be performed to various depths by changing interval between electrodes. To measure ground resistivity 2 other electrodes introduced, 4 lying on straight line at equal intervals a. Current, I, passing between two outer electrodes, and voltage, V, between two inner electrodes, recorded. Uniform resistivity ρ is given by Wenner's formula: $\rho = 2\pi a\, V/I$. If not uniform, observed value will be called "apparent resistivity." It is change in apparent resistivity with electrode separation that allows deductions to be made concerning disposition of rock resistivity. Problems which may be examined by these methods are (*a*) location of water directly by resistivity effects, or indicrectly by location of geological structures favorable to its accumulation, and (*b*) examn. of foundations for reservoirs, dams, etc. This method of search employed extensively in many parts of world, particularly in Africa. Another application, using qualitative interpretations, consists of locating outcrop of water-bearing bed below surface layer. Where depth determinations involved, as in foundations, interpretation difficult. Against disadvantages, which apply only in certain cases, must be set fact that field survey relatively cheap and rapid in operation. Seismic method based on propagation through rocks of shock waves, set up by explosion of buried charge. Speed of waves depends on elastic properties of rocks and their densities. Since both vary through wide range, there is considerable variation in speeds for different rocks. Due to some limitations of resistivity method, tests carried out with seismic method and adopted in '38 as standard procedure for such investigations. —*H. E. Babbitt.*

California Treasures Her Snow for the Summer. FRED H. PAGET. Wtr. & Wtr. Eng. (Br) **50**:91 (Feb '47) All water used in Calif. during summer months, when no rain falls, must be supplied from pptn. of snow at high altitudes during preceding winter. Div. of Water Resources of State Dept. of Public Works has organized snow survey to measure snow on high watersheds so that accurate forecast can be made of amt. of runoff. Measurements include detn. of water content and density as well as depth of pack. During first week of April 150 snow surveyors are out. Predictions cover four months period April 1 to July 31, representing 60% year's runoff. Practical applications wide and varied. In '31 when pack indicated serious shortage, steps were taken early in year to conserve water. Farmers who otherwise would have invested

in such crops as rice were spared financial loss of crop failure. Power companies are able to est. amt. of power they can generate from runoff. When heavy runoff is indicated potential flood menace can be minimized by carrying reservoirs at low stages. In '37, when large flows were predicted for Kern R. and Kings R. early start on protection work saved many thousands of acres of agricultural land from inundation.—*H. E. Babbitt.*

Reclamation of the Ravine Lands of the Jumna, United Provinces. H. L. CHIBBER. Science and Culture. (India) p. 264 (Dec. '46). To grow food for 400,000,000 people every available piece of ground in India should be cultivated and ravine lands of R. Jumna should be reclaimed and utilized. These lands are semi-arid with rainfall confined to June-Oct. River generally bounded by cliffs, slopes being rather steep near river and well suited for action of rain and running water and formation of small gullies and ravines. First, there may be main ravine and later lateral ravines, process repeating until land carved out into deep ravines which are lost to agriculture. Sometimes ravines may extend mile or more on either side of river and along affluent land likewise extensively ravined for considerable distance. Soil fertile on whole, being alluvial in character. Water pumped from Jumna would convert these tracts into arable land; in semi-arid lands where water scarce, drought-resisting crops cultivated and fields prepd. to permit max. soaking of rain water and conservation of monsoon water. Means described for reclamation of ravine lands; even by manual labor in small holdings, peasants with hired labor could terrace and ridge ravine lands. For quick work mchy. would be advisable; with help of bulldozer, steep hilly wastes have been reclaimed and leveled. Quick growing trees and grasses would check erosion and latter provide pasture for cattle. R. Ganges has few ravine lands on small scale; this river is raising its bed (broad and with shifting water channels) by deposits of sediment; during monsoons, when in spate, river overflows and forms marshes or swamps; remedy for this being drainage, training embankments, etc. Author states that ravine lands developing in vicinity of other rivers.—*Ed.*

The Economic Status of the Water Hyacinth in Louisiana. JAMES NELSON GOWANLOCH. Louisiana Conservationist **2**: 9: 3 (Aug. '44). Water hyacinths (*Eichornia crassipes, Piaropus crassipes*), most serious plant pest in Louisiana, originally introduced from Japan to South America where now widespread. Imported from Venezuela in 1884 by Japanese attaches for souvenirs to their visitors at International Cotton Exposition, New Orleans. Carried as gifts over Gulf States, its disastrous proliferacy started agitation for control in 1890. Congress appropriated $5000 for its study in 1897; subsequent acts for removal passed in 1899, '02 and '12. Buoyed by hollow tissues, plant floats high and propagates luxuriantly by both seeds and offshoots to give sometimes 3 mature crops per season. Economic damage consists in impeding navigation to shrimping areas, oyster beds and coastal oil fields; blanketing of water so fish either migrate or starve, since screening of light prevents growth of submerged plants and small animal life it supports; consumption of migrant duck food supply by American coots feeding before their arrival; and promotion of anopheline mosquitoes, a vector of malaria, breeding in some areas though not in others. Association with alligator weed (*Achranthes philoxeroides*) forms dense mats, although hyacinths can frequently support 170-lb. man. Control measures divided into: chem., flame-throwing, mech. and biol. Use of sodium arsenite spray, which withered plants in 2 wk., abandoned in '37 after poisoning boat's crew. Ammonium sulfamate allows unaffected submerged stalks to produce new shoots. In expt. by Wunderlich, soaking clusters with gasoline and burning did not prevent fresh green growth within a week from unharmed submerged portions. Commercial flame thrower allowed similar regrowth. Flame throwers also useless against water chestnut (*Trapa natans*). Mech. eradication may involve either removal of hyacinths to banks where they dry out and die, or maceration of structures by crushers so that vegetative reproduction is impossible from pulp dumped back into water. Two portable units, costing $1400 each, capable of clearing 1200 sq.yd./hr. of vegetation, transported on auto trailer for past 2 yr. by Louisiana Wildlife & Fisheries Div. of Dept. of Conservation. Biol. control unsuccessful to date; when parasites found on moribund tissues their presence apparently incidental.—*A. A. Hirsch.*

The Clutha River. A. J. MCD. MILLER. New Zealand Eng. p. 52 (Jan. 10, '47). Catchment and some problems of river dealt with. Area of 8000 sq.mi. drained by river but natural vegetation burned off and overstocked so large spaces now bared to denuda-

tion; upper catchment mountainous and traversed by large U-shaped glacial valleys, lower catchment drained by several rivers, below one of which is rolling country grassed and cropped, farther on, river has built flood plain developing into a delta from Balclutha to sea and, dividing in 2 branches, fork island of Inchclutha; this lower part forms best cropping lands in New Zealand rendered fertile by deposits of up-country silt. Suitable area for afforestation enormous but apart from State Forest Service very little work has been done; steep or undulating watershed lends itself to erosion which, by wind, other agencies named, together with low but intensive rainfall, has caused cutting down of crops. River erosion confined to Clutha's affluents and to those parts of Clutha not confined in rock gorges; problem of combating erosion in delta where banks are of silt expensive one, acres of land have been lost and only real success achieved with rip-rap rock costing £150 per chain; banks shaped as far as practicable to about 45°, rock tipped in and generally settles to angle of 35°. As a general principle to minimize erosion danger, author recommends partially cutting and felling willows into the river in the concave bends, willows cut working upstream and secured by wire to their stumps, silt then settles in and a reinforced mattress obtained. Changes in river regimen numerous and loads brought down testify to meandering towards sea of new mouths created. In one case when mouth became silted up, work had started on blasting new tunnel when flood arrived and worked out 2 mouths; as a result the 2 branches were shortened and effect on river regimen would be to increase veloc. and transporting power of stream and its ability to erode, but transporting power not enough to carry increased load of detritus and sections began to shoal rapidly, river had been totally changed from a silt carrying to a gravel transporting flow using surplus gravel to aggrade its bed in sections, leaving heavy deposits in bends. Silting problems met with in other New Zealand rivers; soln. is soil erosion prevention so that soil may stay in its proper place and not load up river systems with detritus expensive to deal with and dispose of. Article illustrated by views of rivers and their banks. (Clutha R. is in southeast of Middle Island, N.Z.).—*Ed.*

Automatic Water Level Recorders for River Gaging. Commonwealth Engr. (Australia) **34**:165 (Dec. 2, '46). Description of automatic water level recorders in use in Australia. B type continuous recorder overcomes disadvantages of earlier types by providing mechanism that gives hydrograph extending over month's time, correct separation of weeks, and possible ranges to cover extreme flood heights. This is done by recording time lengthwise on drum with automatic reversing device so 1 wk. recorded in one lateral run. By recording rise and fall on circumference, much greater range can be obtained. Details for constr. and installation given.—*P.H.E.A.*

Floods in Ohio: Magnitude and Frequency. WILLIAM P. CROSS. Ohio Water Resources Board, Bul. 7 (Oct. '46). A 154 p. study of flood flows at 44 stations in 15 river basins in Ohio. Data are analyzed by annual flood method and by partial duration series method. Data are arranged to permit user to apply other methods. Annual flood method extensively used since each flood is independent item not affected by other items in probability series. Objection made that this method omits many floods which are higher than some floods, since only one flood per year is included. The partial duration series meets this objection but introduces one of floods not being independent. Important difference exists in the meaning of the recurrance interval in the two methods of plotting. In annual flood series it is avg. interval in which a flood of given magnitude will recur as an annual max., whereas for partial duration series it is avg. interval between floods of given size regardless of time. For bridges, etc., the former should be used, whereas for culverts in which damages can be quickly repaired, latter may be used. Both series give approx. identical result, however, for intervals of greater than 10 years. Considerable discussion on skewness of probability curves as applied to flood flows; also a 21-item bibliography. Data for each of 44 stations tabulated and plotted by each method. Conclusion reached that, considering wide range of probable error, use of elaborate mathematical processes in flood flow study is questionable. Damage involved in extrapolating from short-term record is apparent.—*O. R. Elting.*

The Flooding of the Lea Bridge Works of the Metropolitan Water Board of London. FRANK WOOD. Wtr. & Sew. Wks. **94**:172 (May '47). Account of disastrous flood of River Lea Mar. 15, '47, which deprived

1,000,000 people of normal water supply for 10 days.—*Ed.*

Cities Built on Water. MIRIAM ROHER. Western City. **23**:3:28 (Mar. '47). Colorado R. Basin is enormous 242,000 sq.mi. expanse covering parts of 7 states. Phoenix, Ariz., only city of over 65,000. Pop. density of 4 per sq. mi. compared to national avg. of 44. Growth depends on water. Bureau of Reclamation studied problem. First large project was Hoover Dam. Completed in '35, it supplies Ariz., Nev. and Southern Calif. Davis Dam being constructed 67 mi. south of Hoover Dam to regulate release and develop power. All-American Canal below Yuma, Ariz., serves Imperial Valley agriculture and communities. Parker Dam 150 mi. below Hoover is diversion point for Metropolitan Water Dist. of Southern Calif. Built in '33, owned and operated by federal govt., carries water to coastal plain of Southern Calif. New aqueduct being constructed carrying water to San Diego. Many small municipalities along Colorado R. using water. Congress says all this not enough. Water still being wasted in 1400-mi. long river while much land needs water. Bureau of Reclamation report outlines 134 potential dams at cost of $3,500,000,000, would make over 2,500,000 acres available for farms or pasturage, develop 38 hydro-elec. plants. Would create vast farming area with resulting growth of communities. Elec. power would develop mining and mfr. Report points out growth of Los Angeles due to Hoover Dam power. Colorado R. power could give employment to 350,000 persons. Development of tourist trade big factor. Taxable wealth would increase greatly due to rise in land values. Bureau believes benefits would far exceed cost. All depends on agreement among 7 states.—*A. C. Rener.*

BOILERS AND FEED WATER

Control of Boiler Water Treatment. J. GUTH. Chaleur & Ind. (Fr.) **28**:33 ('47). One French deg. of hardness defined as 10 mg. $CaCO_3$ per l., and equivs. given for other compds. found in boiler water. Methods of anal. given for: hardness; alkalimetric titrations with phenolphthalein and with methyl orange, from which content of bicarbonates, neutral carbonates, and caustic alkalies can be calcd.; phosphates; D.O.; and salt concn. or total salinity of boiler water. Sampling methods also given, and use of analytical results in control of chem. treatment of feed water and control of alky., concn., blowdown, etc., for boiler water.—*C.A.*

What Water Treatment Has Done for the Railroads, and What Is To Be Done To Further Improve Locomotive Boilers. JOHN F. POWERS ET AL. Master Boiler Makers Assn. Proc. 187 (1946). Water treatment was important factor in successful operation of American railroads during World War II and permitted handling of enormous war traffic without any of the serious interruptions to train movement which were rather frequent when untreated water supplies used. Water treatment program made possible longer runs of steam locomotives, permitted use of high power locomotives, reduced fuel consumption approximately 50,000,000 tons per year, saved a substantial tonnage of steel, contributed largely to the high availability of steam locomotives which permitted 42,000 locomotives to perform twice the work done by 64,000 locomotives during World War I, reduced shopping time of locomotives to the minimum required by machinery repairs and contributed to a performance record of virtual elimn. of boiler failures. Discussion of report indicated that trouble with intercrystalline cracking from rivet holes in boiler shells still being experienced on some railroads and further investigation and report is planned.—*R. C. Bardwell.*

Inhibition of Hard Scale in Boilers and the Action of Static Charges on Colloids. E. J. B. WILLEY. J. Soc. Chem. Ind. (Br.) **65**:533 ('46). Two systems each give remarkable results in treatment of feed water. One an electrode system consisting of rod inside tube through which water circulates. Difference of potential of about 26 v. maintd. between rod and tube. Other system evacuated glass cylinder contg. Hg. This cylinder is jacketed by concentric glass cylinder with $\frac{1}{8}$" clearance between the two. This system is suspended in water and moved by action of water or by another source. Ext. charges develop next to Hg as it moves about in bulb. Two systems appear to be similar in their action, which seems to involve colloids in water; this

enables them to undergo strong adsorption at surface of nascent crystals and cause crystal forms that normally appear only when large amts. of boiler-treating compds. used. Both methods of treatment result in dendritic scale, about 35% less by wt. than scale formed in control systems. Static charges seem able to exert strong influence on rate of reaction of positive solns. and negative solns. with each other.—*C.A.*

A Theory of Carry-Over. A. R. MUMFORD. Combustion **18**:8:39 ('47). Based on idea that chems. in water from which steam is made concd. in film surrounding steam bubble, theory proposed relating operating pressure and chem. concn. to steam contamn. If each steam bubble is surrounded by such highly concd. film of high surface tension and strength, necessary to agitate these bubbles violently with boiler water to reduce film concn. and weaken film to deg. that will allow it to burst and release steam. As boiler water concn. increases, bubble film concn. and strength increase and the separating and purifying equip. may become overloaded and unable to destroy strong bubble films.—*C.A.*

Carry-Over Problems Solved at Eaton Plant. E. C. GASTON. Southern Power and Ind. **65**:1:60, 94 ('47). Excessive carry-over in steam encountered in this plant operating at approx. 850 lb. gage and 880–890°F. steam temp. Internal treatment with NaOH, phosphate, and NaCl had been used; elimn. of NaCl reduced solids in boiler water but turbine deposits still formed. Use of Na_2SO_3 at rate sufficient to give residual of 10–20 ppm. in boiler water elimd. deposit formation as well as any O remaining in H_2O. SiO_2 in feed water should be held at 5 ppm. or below, and SiO_2 concns. in boiler water must be kept below 250 ppm. at all times.—*C.A.*

Difficulties in Creating Scale-Free Conditions in Boilers With Stepwise Evaporation. YU. M. KOSTRIKIN. Izvest. VTI **15**:11:23 ('46). Phosphate ion and silicate ion effective in preventing boiler scale by pptg. Ca and Mg ions, resp. Scale will form when SiO_3^{--} ppts. Ca^{++} and PO_4^{---} ppts. Mg^{++}. Based on soly. products of compds. which these 4 ions may form, anal. made to det. conditions preventing boiler scale in presence of all 4 ions. Such conditions feasible, but only within narrow limits. At small salt concns. impossible to create favorable conditions. Under such circumstances $Mg_3(PO_4)_2$ will ppt. first, forming scale. $Mg_3(PO_4)_2$ will also form when concn. of SiO_3^{--} is considerable. Generally possibilities of establishing favorable conditions in boilers with stepwise evapn. quite limited.—*C.A.*

Calculating the Quantity of Alkaline Precipitation Reagents for In-boiler Water Treatment. I. F. SHAPKIN. Vestnik Inzhenerov i Tekh. (U.S.S.R.), **6**:179 ('46). Quant. of reagents required for pptg. noncarbonate scale formers, plus that carried away by steam, and that carried away by blowdown is $G = D[N + \varphi(A + N) + a]$ ton deg. per hr., and quant. needed per hr. is $G = D[N + \varphi(A + N) + a]k/\epsilon$ g./hr., where D is avg. hourly load of boiler in tons, N is noncarbonate hardness of water in German deg., φ is deg. of blowdown, i.e., ratio of avg. hourly quant. of blowdown water (B) to D, A is total alky. of boiler water in German deg., a is total alky. of steam in German deg., k is equiv. in g. of ton deg. of given reagent, and ϵ is deg. of purity of reagent. For NaOH, k is 14.27; for Na_2CO_3, 18.9; for $NaHCO_3$, 30.0; and for $Na_3PO_4.12H_2O$, 45.2 g. Value of a should be detd. directly, or assumed to be 0.5 for fire-tube boilers and 1.0 German deg. for water-tube boilers. If losses through steam and blowdown considerably smaller than N, formula simplified to $G = DN$ ton deg. per hr. or $G = DN(k/\epsilon)$ g./hr. When precipitant added as soln. its quant. is calcd. from $Q = D[N + \varphi(A + N) + a]1000/Ar$, where Q is vol. of reagent in l./hr. and Ar is total alky. of reagent in German deg. detd. by titrating very dil. soln. with 0.1 N acid to methyl orange. If part of water softened by passing it through base exchanger, part of water to be thus treated (y) in order to ppt. hardness in rest (untreated) of water is given by $y = (N + a(1 - \varphi) + \varphi A)/H$, where H is total hardness of raw water in German deg. When losses through steam and blowdown negligible, $y = N/H$. Frequency of adding reagent (τ_1) given by $\tau_1 = (A_1 - A_2)W\gamma/D[N + \varphi(A + N) + a]$, where A_1 and A_2 are upper and lower limits of admissible alky. in German deg., W is water capac. of boiler in cu.m., and γ is wt. of water at given temp. in tons per cu.m. Simplified formula is $\tau_1 = (A_1 - A_2)W\gamma/DN$. If τ_1 less than 10 hr., advisable to feed reagent continually.—*C.A.*

Composition for Preventing Boiler Scale. V. I. FRYDMAN & A. A. RAMLOV. U.S.S.R. 64,403 (Feb. '28, '45). Brown coal ground in

aq. soln. of 8–10% (on wt. of coal) of alkali to form colloidal suspension. Suspension allowed to settle and solids sepd. To filtrate is added Na phosphate and product used to prevent boiler scale. Grinding in an alk. medium extracts substances of lignite type, which possess anti-scale properties and are also stabilizers for colloidal particles of coal.—*C.A.*

Analysis of Boiler Water for Its Content of Silicic Acid and Excess Phosphates. YU. M. KOSTRIKIN & E. G. KOCHNEVA. Izvest. VTI (U.S.S.R.) **15**:11:25 ('46). Purpose of phosphate ion in boiler water is to ppt. Ca as $3Ca_3(PO_4)_2.Ca(OH)_2$ (hydroxyapatite), which does not form boiler scale. Mg should be pptd. as $MgSiO_3$, in which form it does not deposit as scale. Since both phosphate and silicate ions detd. conveniently as Mo complexes, essential to separate them in anals. In outlined procedure advantage taken of differences in acidity at which complexes are formed and at which they are stable. Thus phosphomolybdate formed at 0.2–1.0 *N* H_2SO_4, and optimum H_2SO_4 concn. for its formation is 0.5–0.7 *N*. At this concn. color produced by reducing phosphomolybdate with $SnCl_2$ also stable. Above 1.2–1.5 *N* H_2SO_4 phosphomolybdate will give no color when reduced. Optimum H_2SO_4 concn. at which silicomolybdate formed is 0.1–0.25 *N*. Once formed, it remains stable at 3–3.5 *N* H_2SO_4 and will develop blue color when reduced. Procedure for detg. $PO_4^{---}$is: Transfer a 10-ml. (or 50-ml. if PO_4^{---} concn. small) sample to 100-ml. volumetric flask. Add 10 ml. of 5.5 *N* H_2SO_4 and 5 ml. of 5% NH_4 molybdate soln., mix, and dil. with H_2O. Add 10 drops of 1% $SnCl_2$ soln., bring to mark, mix thoroughly, and, after 2 min., det. color in colorimeter. To det. SiO_3^{--} place 10–40-ml. (depending on SiO_3^{--} content) sample in 100-ml. volumetric flask. Add 1 ml. of 10 *N* H_2SO_4 and enough H_2O to make total vol. 41 ml. and add 10 ml. of 5% NH_4 molybdate. Acidity of soln. now around 0.2 *N* H_2SO_4. Mix and after 3 min. (yellow silicomolybdate complex formed) add 25 ml. of 10 *N* H_2SO_4 to destroy phosphomolybdate complex if present. Acidity now around 3.4 *N* H_2SO_4. Mix, add 10 drops of 1% $SnCl_2$ soln., bring to vol. with H_2O, mix thoroughly, and det. in colorimeter after 5 min.—*C.A.*

Measurement of Corrosion Pits in Boiler Tubes. B. M. THORNTON. Engineering (Br.) **163**:229 (Mar. 28, '47). Methods of boiler feed water treatment are now so perfected that trouble is rare but occasions arise to cause anxiety. In majority of cases corrosion troubles are confined to well-defined place in boiler and maint. engrs. know where to look for them. Exhaustive survey of complete tube can be made at fraction of cost of removing and replacing it. When testing tube, head (of instrument) is made to traverse tube. When pit is encountered there is sharp fall in reading. Although it would be possible to measure depth of pit, information required is whether serious pitting is present. —*H. E. Babbitt.*

Removal of Silica From Water. PAUL C. GOETZ. U.S. 2,401,924 (June 11, '46). Silica compds. removed from boiler feed water by intimately mixing water with sludge contg. relatively high content of Mg compds. in form of MgO and $Mg(OH)_2$. Only relatively small amt. of Mg compd. (such as calcined dolomite) need be added for each batch of H_2O treated and corresponding volume of sludge dischgd. More complete Si removal realized by prelim. bringing into contact of water with sludge to absorb Mg ions, which are then pptd. as water meets freshly added reagent. Treatment should be at temp. above 50° and preferably above 80°C. This process may be combined with lime-soda water softening or used to remove Si from relatively soft water. In several examples reported, Si content reduced to 1.6 ppm.—*C.A.*

Removing Silica From Boiler Water. WALTER LEAF. Ry. Eng. & Maint. **43**:684 (1947). New process for removing dissolved silica from water, developed in lab. of Denver & Rio Grande Western Ry., consists in rusting iron in form of cast-iron borings in the presence of the water being treated. Tests indicated that the formation of Fe_2O_3 in the SiO_2-bearing water absorbed or sequestered the soluble SiO_2 in such form that hard scale was elimd. in boilers over 6 months' operation. Neither Fe_3O_4 nor pptd. Fe_2O_3 had appreciable absorptive capac. compared with the Fe_2O_3 formed by rusting in presence of SiO_2-contg. water. Plant test with deep well water at Alamosa, Colo., containing 85–170 ppm. SiO_2 showed a reduction to below 17 ppm. by this method and greatly improved results in condition of operating boilers. Air agitation is used and cast-iron borings must not be allowed to cake and prevent metal from producing fresh rust.—*R. C. Bardwell.*

Removal of Silica From Boiler Feed Water. M. LEVIEL. Chaleur et ind. (Fr.), **27**:195 ('46). Various methods of removing SiO_2 from boiler feed water reviewed, and specific recommendations made. Silica scale gives little trouble with boilers operating at low pressures and relatively high alky.; when silica content of H_2O relatively high, continuous blowdown can be initiated and suitable addns. of Na_3PO_4, Na aluminate, or powd. Fe made. At higher pressures, aluminate can be added to cold-lime process and Fe or salts of Mg to soda process; other suggestions for reduction of SiO_2 include addn. of powd. MgO in hot-lime process or use of calcined dolomite instead of CaO. SiO_2 content of H_2O with low mineral content can be reduced by filtration through metallic hydrates or Mg compds. or by addn. of MgO powder. Water from simple soda process can be treated similarly. Silica should be removed as completely as possible from feed water for h.-p. boilers in which only low alkalinities can be maintd.; blowdown program assumes importance here. Chem. processes for removing SiO_2 leave residual content of 1 mg. SiO_2 or more per l., and blowdown must be based on SiO_2 content rather than on total solids. Direct elimn. of SiO_2 by exchange supplemented by addn. of fluorides will give feed water contg. less than 0.1 mg. SiO_2 per l., so that with blowdown of 2.5% of makeup SiO_2 content of boiler water should not exceed 4 mg./l.; this gives considerable margin of safety. SiO_2 detns. can be made before and after adsorption of colloidal SiO_2 on $Fe(OH)_3$; colloidal SiO_2 detd. by difference. SiO_2 can be detd. gravimetrically by Duval method. For plant use, colorimetric method with ammonium molybdate and Dubosc colorimeter suggested, but necessary to elim. all traces of Fe and phosphate in sample and to make frequent blank tests on reagents. Latter method does not det. colloidal SiO_2; ordinarily this can be neglected in control anals.—*C.A.*

Noncorroding Water Heaters. Business Week, 875:47 (June 8, '46). Because electrolytic corrosion, particularly in acid-charged water areas, will attack even special alloy hot-water tanks, McGraw Elec. Co. (Chicago) has perfected the "Ionodic" system for new Clark elec. water heaters. Rod of pure magnesium inserted in steel tank and in presence of water forms galvanic battery. Current produced causes magnesium to go into soln. and protect steel. Although basic principle not new, this development incorporates resistance between magnesium and steel to limit current flow and retard rate at which magnesium consumed.—*Ed.*

CORROSION

Corrosion of Buried Pipes. Sulfate-Reducing Bacteria. ANON. Surveyor (Br.) **106**:139 (Mar. 7, '47); Wtr. & Wtr. Eng. (Br.) **50**:203 (Apr. '47). Prof. R. P. Linstead estd. loss from corrosion of buried pipes as £30,000,000 per year. Importance of corrosion of metals, particularly ferrous metals, well known. Corrosion of ferrous metal immersed in water occurs by electrochem. mechanism. There are certain agents that can take place of oxygen in acting as depolarizers, so that corrosion can go on anaerobically. Such agent is provided by sulfate-reducing bacteria, known for 50 yr. First isolated from canal mud in Holland. Org. carbon not essential for growth; vibrio will live in presence of oxygen; iron essential growth factor. Iron pipe, buried in subsoil under anaerobic conditions, will first undergo corrosion by ordinary galvanic process: $Fe + 2H_2O \rightarrow Fe^{++} + 2OH^- + 2H$; ferrous iron will dissolve at anode and H will be discharged at cathode. Bacteria reduce sulfate surrounding cathode to sulfide, oxygen being used up in chain of bact. reaction terminating with removal of depolarizing hydrogen: $H_2SO_4 + 8H \rightarrow H_2S + 4H_2O$. All parts of this hypothesis have not yet been tested. Concurrently with fundamental investigations field trials have been carried out.—*H. E. Babbitt.*

Pump Cavitation. B. R. WALSH. Oil & Gas J. **45**:23:99 (Oct. 12, '46). Remedies for cavitation classified as: (1) Reduction of pump entry loss to absolute min., by reduction of peripheral speed or clearance vol., use of side pockets and incorporation of pickup blades or ports and enlargement of inlet passage with elimn. of turns and bends; (2) Increase of pressure available at pump inlet by reduction of inlet line loss, increase of liquid supply head, installation of centrifugal booster (for positive-displacement pumps), pressurized supply tank, elimn. of entrained air (and dissolved air, if feasible).—*Corr.*

Report of the Copper Tubes Committee. R. P. VAN ROYEN ET AL. Netherlands Water Works Assn. 184 pp. Investigations with test installations, both cold and hot water, extended over 12 water supplies, representing principal types of water occurring in Holland. Tinned copper tubes must contain tin layer free from pores; amt. of Cu passing into soln. in 30 min. in 2% ammonium persulfate soln. must not exceed 0.5 mg./100 sq.cm. tinned surface. Amt. of tin present must be at least 30 gr./sq.m. surface. Lead content of tinning material may not be more than 0.5%; tin content at least 98.5%. Quant. of copper in water, coming from pipe which has been in use for at least 3 mo., must not amt. to more than: (1) 3 ppm. for water retained in pipe for 16 hr. (2) 2 ppm. obtained from any tap at normal rate of flow, while amt. of arsenic as As should not be more than 15 γ and 10 γ. Quants. of Cu and As found in various supplies given. Copper tanks contg. As (0.25–0.45%) not objectionable. Striking relation between HCO_3^- content of water and Cu content found; higher HCO_3^- greater amt. of Cu in soln. D.O. content of water found most important factor governing dissolution of Cu from tube walls, followed by pH of water; dissolution of Cu being favored by low pH. Copper tubes attacked by water produce hydrated copper oxide and (possible basic $CuCO_3$), ratio of 2 products deposited as a layer, depending upon CO_2 content of water to extent that amt. of $CuCO_3$ generally increases with increases in CO_2. Layer formed not homogeneous and of different color (green, brown) in different places, giving impression of iron or org. deposits. With negatively chalk-aggressive water, $CaCO_3$ can separate this occurrence, but not with aggressive water. Considerable quants. of tin oxide formed by action of water on tinned copper tubes; this occurs most strongly in water with excess bicarbonates. It appears that in addn. to SnO_2, compds. of Ca, Cu, Fe, silicic acid and carbonic acid occur in coating. Evidence of tin-pest found after intense frost. Connection of copper tubes to one another, to app. and accessories, described at length, particularly soldering and welding, clamp fittings and screw fittings. Joining lead and copper tubes has tendency of dissolution of both Cu and Pb around joints, but there is no objection to joining Cu and Pb tubes by soldering. On basis of results following general rules are drawn: use of untinned copper for transport and storage of hot and cold water permissible if walls continuously in contact with water, except if pH calcd. from free CO_2 and HCO_3^- contents is 6.9 or lower, while at same time dissolved O greater than 3 ppm. Tinned copper or copper with tin lining can be used. In doubtful cases, where pH less than 7.1 and higher than 6.9, water contains 50 ppm. or more NO_3, has 5 ppm. NH_4^+, or in addn. contains excess of HCO_3^-, test installations are set up or tinned copper used.—*W. Rudolfs.*

The Ortho- and Poly-phosphates for Water Treatment. G. CORSARO. Natl. Engr. **51**: 106 ('47). Chemistry, properties, and action of phosphates discussed, also, control of Fe by means of threshold treatment. Polyphosphides provide basis of scale, Fe, and corrosion control. Believed that colloidal complexes formed deposit on metal or metal oxides to form coating that protects them from O_2 and CO_2 attack.—*C.A.*

A Review of Inhibitors. W. G. IMHOFF. Wire and Wire Products. **21**:6:447 (June '46) 7:520 (July '46); 8:598 (Aug. '46); 9:621 (Sept. '46). In reviewing this field of pickling, early records of cleaning and pickling, inhibitors and various materials mentioned as addn. agents, foam compds., classification, sulfuric acid mfr. and inhibitor theories discussed. Record of inhibitor patents from '83 to '46 given. Bibliography.—*Corr.*

Acid-Proof Coatings for Water Conditioning Installations. A. P. MAMET. Izvest. Vsesoyuz. Teplotekh. Inst. (U.S.S.R.) **15**:3:24 ('46). Abstracted C.A. Of various coatings of acid proofing materials tested on parts of water treating installation, perchlorovinyl varnish very effective; rubber chloride still more effective, but supply limited. Polychlorovinyl and its products used successfully on surfaces which were not sharply curved. Where elasticity not required mixt. of divinylacetylene polymers and Rubrax performed well. Latter alone unsatisfactory. Ordinary enamel and automobile lacquer failed.—*Corr.*

A New Stray Current Control System. Pipe Line News. **18**:11:24 (Nov. '46). This system, announced by Cook Research Labs., said to prevent damaging effects caused by electrolytic action on underground pipe installations. System described as current and voltage-sensitive device, functioning of which depends on amt. of current or potential present in pipe.—*Corr.*